

**BIOEFFICACY OF INSECTICIDES AGAINST SUCKING
PESTS OF *Bt* COTTON AS STEM APPLICATION**

By

**Mr. KHAIRE SUGAT DNYANESHWAR
(Reg. No. R/13/099)**

A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413722, DIST. AHMEDNAGAR
MAHARASHTRA STATE (INDIA)**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413722, DIST. AHMEDNAGAR
MAHARASHTRA STATE, INDIA
2015**

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MAHARASHTRA, INDIA**

2015

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part of this thesis

has not been submitted by me or any other

person to any other University

or Institute for a Degree

or Diploma.

Place: M.P.K.V., Rahuri.

Date : / / 2015

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CERTIFICATE

This is to certify that the thesis entitled, **BIOEFFICACY OF INSECTICIDES AGAINST SUCKING PESTS OF *Bt* COTTON AS STEM APPLICATION** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist-Ahmednagar, Maharashtra, India, in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** embodies the results of a piece of bonafide research work carried out by **Mr. KHAIRE SUGAT DNYANESHWAR**, under my guidance and supervision and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation has been duly acknowledged.

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This is to certify that the thesis **BIOEFFICACY OF INSECTICIDES AGAINST SUCKING PESTS OF *Bt* COTTON AS STEM APPLICATION** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist-Ahmednagar, Maharashtra, India, in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** embodies the results of a piece of bonafide research work carried out by **Mr. KHAIRE SUGAT DNYANESHWAR**, under the guidance of **Dr. U. B. HOLE**, Associate Professor of Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri and that no part of the thesis has been submitted for any other degree or diploma.

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Date : / /2015

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Place : MPKV, Rahuri.

Date : / / 2015

(S. D. Khaire)

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LIST OF ABBREVIATIONS

%	: Per cent
/	: Per
@	: at the rate of
>	: More than
°C	: Degree Centigrade (Celsius)
a.i	: Active ingredient
am	: Anti-meridian
BSH	: Bright Sunshine Hours
cm	: Centimetre (s)
Conc.	: Concentration
DAS	: Days after sowing
DAA	: Days after application
SL	: Soluble liquid
e.g.	: Exempli gratia
EC	: Emulsifiable concentrate
<i>et al.</i>	: and others or et alii
etc.	: Et ceteras or so on
Fig.	: Figure (s)
G	: Gram((s)
ha	: Hectare (s)
hr	: Hours(s)
i.e.	: id est or that is
LBB	: Lady bird beetle
lit.	: Litre
log	: Logarithm
M.P.K.V.	: Mahatma Phule Krishi Vidyapeeth
mg	: Milligram
ml	: Millilitre

MW	:	Meteorological weeks
No.	:	Number
pp.	:	Pertaining pages
qtl.	:	quintal
r	:	correlation coefficient
RH	:	Relative humidity
RH-I	:	Morning relative humidity
RH-II	:	Evening relative humidity
S.E.	:	Standard error
sp./spp.	:	Species
T _{max}	:	Maximum temperature
T _{min}	:	Minimum temperature
<i>viz.</i> ,	:	Videlicet (namely)

ABSTRACT

BIOEFFICACY OF INSECTICIDES AGAINST SUCKING PESTS OF *Bt* COTTON AS STEM APPLICATION

By

Mr. KHAIRE SUGAT DNYANESHWAR

A candidate for the degree

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MASTER OF SCIENCE (AGRICULTURE)

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AGRICULTURAL ENTOMOLOGY

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Research Guide	:	Dr. U. B. Hole
Discipline	:	Agricultural Entomology

The present investigation on “Bioefficacy of insecticides against sucking pests of *Bt* cotton as stem application” were undertaken at All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri during May 2014 to January 2015.

The study of population dynamics of sucking pests of *Bt* cotton was undertaken from June 2014 to December 2014. The aphid incidence per 3 leaves ranged from 1.15 to 80.77 and the maximum population was recorded in 40th MW. The positive correlation was found to exist between aphids incidence and metrological parameters ($T_{\min}=0.02$, RH-I=0.14, RH-II=0.08 and) except $T_{\max}$ i.e -0.10 and Rainfall=-0.24.

Incidence of jassids during experimental period ranged from 1.77 to 14.95 jassids per 3 leaves. The maximum population was noticed in 32thMW. The jassid population was found negatively correlated with $T_{\max}=-0.32$ and Rainfall=-0.11, while positively correlated with $T_{\min}=0.19$ and relative humidity (RH-I=0.38 and RH-II=0.48), respectively. While, highly significant positive correlation was found with

Abstract conti..

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RH-II (0.48) i.e. relative humidity during evening hours.

The incidence of thrips during experimental period ranged from 0.00 to 50.51 per 3 leaves. The peak incidence of thrips was found in 34th MW. It could be seen that thrips population was found positively correlated with $T_{\min}$ (0.16), relative humidity (RH-I=0.45 and RH-II=0.49) and Rainfall (0.36) and negatively correlated with $T_{\max}$ (-0.36). However, highly significant positive correlation was found with relative humidity.

The incidence of whiteflies during experimental period ranged from 1.92 to 29.19 per 3 leaves. The peak incidence was observed in 44th MW. During the studies the whiteflies population was negatively correlated with temperature ($T_{\max}$ =-0.48 and $T_{\min}$ =-0.54), while positively correlated with relative humidity (morning=0.03 and evening=0.21) and rainfall (0.09), respectively.

It is observed that activity of predators was found in the range of 1.09 to 19.48 per plant. The maximum population was observed in 40th MW. It could be seen that natural enemies population was found to be negatively correlated with maximum temperature (-0.15) and rainfall (-0.17) while positively correlated with minimum temperature (0.02), morning and evening relative humidity (RH-I=0.23 and RH-II=0.14), respectively.

On the basis of efficacy of various pesticides observed in the present investigation that three applications of monocrotophos 36 SL, oxydemton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution is effective in controlling

aphids, jassids and whiteflies. Similarly, monocrotophos 36 SL, oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:4 dilution were effective in controlling the cotton thrips. Among the different chemical treatments, monocrotophos 36 SL @ 1:4 dilution was found to be the most effective for the suppression of sucking pests while profenophos 50 EC @ 1:4 dilution found inferior among all the treatments. The treatment malathion 50 EC @ 1:4 dilution was found most safer to natural enemies (LBB and *Chrysopa*).

Among the chemical treatments the highest yield was recorded from monocrotophos 36 SL, oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution by giving effective control of sucking pests. The highest ICBR (1:7.52) was obtained in oxydemeton methyl 25 EC followed by monocrotophos 36 SL (1:7.48) and carbosulfan 25 EC @ 1:4 dilution (1:7.04).

1.INTRODUCTION

Cotton (*Gossypium* spp.), “The Queen of fibres”, is an important cash crop under diverse agro-climatic conditions around the world. By far, cotton is the most important natural fibre or vegetable wool, has been in commercial cultivation for domestic consumption and export needs in about 111 countries worldwide and hence called “Queen of fibres” or “white gold”. Cotton plays an important role in the agriculture and industrial activities of the nation and it has a unique place in Indian economy and social affairs. It provides livelihood for about 4 million farming families. It also provides 65% raw material to textile industry and contributed 1/3rd of total foreign exchange earning of India (Mayee and Rao, 2002).

Cotton, cotton-related products, textiles and apparel are economically important commodities and consist of agricultural and industrial sectors in India. With suitable climate for cotton cultivation across the country and with improved technologies from public and private sectors, the cotton production in the country is expected to touch the all-time high of 400 lakh bales of 170 kg in the year 2014-15. In the past ten years from 2004-05 to 2013-14, remarkable cotton area and production increase were achieved with cotton area enhancement of 31% and production enhancement of 54%. Cotton Advisory Board estimates around 3.5% drop in area under cotton from 117.27 to 126.55 lakh ha in 2014-15 compared to previous year. Gujarat and Maharashtra continued as a leading cotton producing states in the country for the past 20 years. Also these two states occupy more than

50% of the total cotton cultivation area in the country for several years. In the current year, the area under cotton production decreased in Punjab and Madhya Pradesh. Out of the total cotton production in the country, long staple cotton production was 77% followed by medium staple cotton 20% and short and ELS 3%.

World cotton production has been estimated at 119.17 million bales of 480 lb in 2014-15 (AICRP Report, 2014). Cotton area has been decreased to the tune of 1.47 million ha compared to 2013-2014. The early estimate of USDA indicates that India has displaced China and become the leading producer of cotton and second largest exporter of cotton next to United States. India also sustained the position of being the second largest consumer of the cotton and is expected to consume 24 million bales in 2014-2015. Australian cotton production has been reduced to 50% due to drastic reduction in area under cotton. Higher productivity continued to maintain this year too in Australia, Brazil, China, Turkey and Mexico. Though the productivity decreased in United States, the production is expected to increase from 12.91 to 16.08 million bales compared to last year. Import of raw cotton reduced from 40.58 to 33.99 million bales and export reduced from 40.72 to 33.99 million bales compared to last year. The leading raw cotton importer china expected to reduce from 14.12 to 7.00 million bales this year compared to last year, however, likely to reserve raw cotton pool of 63 million bales this year, which is more than half of the current world raw production.

Sucking pests cause considerable damage in the

initial days of *Bt* cotton growth. Of these, damage caused by jassids, aphids and thrips is more, which is quite apparent from the fact that the production is not in pace with the increase in area. Decline in production is mostly due to sucking pest complex in *Bt* cotton hybrid. The present control strategies adopted by the growers are mostly based on the use of chemical insecticides by spraying which not only controls the harmful insect pests but also they are harmful to beneficial insects. Besides this, it causes ecological imbalance and result in severe multiplication of pests due to reduced population of natural enemies. With a view to manage the sucking pest complex in early growth stages of *Bt* cotton and to protect natural enemies, insecticides can be applied on stem by stem application technique which is cost effective and eco-friendly instead of spraying. Realizing the need to incorporate effective ecofriendly pest management measures in IPM program, the present study has been undertaken with the following objectives.

1. To study the seasonal incidence of sucking pests in *Bt* cotton.
2. To study the efficacy of insecticides as stem application against sucking pests of *Bt* cotton.
3. To study the effect of stem application of insecticides on natural enemies of *Bt* cotton.

2. REVIEW OF LITERATURE

The present investigation was aimed to assess the bioefficacy of chemicals viz., imidacloprid 17.8 SL, oxydemeton methyl 25 EC, monocrotophos 36 SL, profenophos 50 EC, carbosulfan 25 EC, dimethoate 30 EC, malathion 50 EC as stem application against sucking pests viz., aphids (*Aphis gossypii*), jassids (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci*) and whiteflies (*Bemisia tabaci*), and effect of these insecticides on population of their natural enemies viz., Ladybird beetle, chrysopa spp., along with yield was studied. The relevant literature collected is given below under different subheads.

2.1 Seasonal incidence of sucking pests in *Bt* cotton

Al- Faisal and Kadou (1986) found that population density of *Thrips tabaci* (Lind) in the middle of Iraq exhibited two peaks on cotton. First is reached in the early May, the second in the end of the June and early July. Nymphs suffered continuous mortality during their growth before reaching adulthood. Growth of the first peak was attributed to some favorable conditions prevailed viz., temperature, relative humidity, age of cotton plant and the absence of natural enemies. Appearance of the predator, *Orias albidipennis*, an competitor aphid on cotton, higher temperature may be the main cause of population decline during May.

Patel and Rote (1995) studied seasonal incidence of sucking pests of cotton (Digvijay) in rainfed condition at Regional Cotton Research Station, Gujarat Agricultural University, Bharach and revealed that the aphids population

was at its peak (43.05/plant) in the second fortnight of October. The population of jassids ranged from 0.59 to 2.78 per plant; while thrips ranged from 0.61 to 4.64 per plant. In case of spider mite, maximum population (17.51) was noted in the second fortnight of November.

Bishnoi *et al.* (1996) conducted an experiment to study the relationship between population build up of cotton pests with environmental variables and reported that significant relationships were observed between population build up of jassids and whitefly with mean air, temperature and relative humidity. Jassids and whitefly incidence was observed at vegetative stage and population increased with the advancement of the season attaining peak at maximum leaf area stage. The optimum temperature and humidity for population build up of cotton pests were 27 to 34°C and 52.82 per cent RH for jassids, 25 to 30°C and 40-58 per cent RH for whitefly during the growing season.

Gupta *et al.* (1997) noticed the incidence of aphids, jassids and thrips at four week stage of crop. Peak population of aphids, jassids and thrips was recorded during last week of July to mid-August (24.8-30.1°C and >87% RH) last week of July to mid-September (24.8-32.6°C) and second fortnight of August to first fortnight of October (30°C and 74-85% RH), respectively. Aphids and thrips did not show any preferences for any of five cotton hybrids (H4, H6, JKH-1, DCH-32 and AHH-468); while jassids population was found to be maximum on hybrid DCH-32 and minimum on AHH-468. Interspecific competition was found to be operating among these species.

Patel *et al.* (1997) studied the effect of weather

factors on the activity of major pests of okra and found that, no significant relationship between the population of aphid, fruit borer and any weather parameter was observed. Significant relationship was observed between leaf hopper level and maximum temperature ($r = 0.76$) as well as hours of bright sunshine ($r = 0.82$).

Mogeni and Rezwani (1998) found that the aphids had a peak activity from August to mid-September at a temperature and relative humidity (RH) 24 to 28°C and 65-75 per cent RH, respectively. Phytocell study indicated that the aphid had a life cycle 6-7 days and longevity 20-26 days ($24 \pm 1^\circ\text{C}$ and $75 \pm 5\%$ RH), respectively.

Kudale (2000) studied the bioecology and management of key pests of arborium cotton and reported that incidence of thrips started from first week of July (26th MW). The maximum population of thrips (14.70 thrips/plant) was observed in fourth week of September i.e. in 89th MW when temperature and relative humidity were 31°C and 83 per cent, respectively. He also observed that there was significant positive correlation between thrips population and maximum temperature and morning relative humidity.

Panickar and Patel (2001) conducted the experiment to study the effect of weather factors and the activity of thrips infesting chilli, cotton and pigeonpea and found that the significant negative relationship between population of thrips on chilli and minimum temperature (0.62), mean relative humidity (0.63) and mean vapour pressure (0.71), thrips had significant positive relationship with wind speed whereas the significant negative relationship

was found between the population of *Megalurothrips usitatus* infesting pigeonpea and mean temperature (0.71).

Bhede (2003) reported that thrips commenced in last week of August and reached peak during first week of October the correlation of thrips population with evening relative humidity and rainfall were negatively significant.

Wan-Pong *et al.* (2003) studied the effect of transgenic Bt cotton on development and population dynamics of cotton aphid both in the laboratory and field and found that there was no significant difference in the population dynamics of aphids and its damage to Bt cotton lines and conventional cotton without chemical control.

Simia *et al.* (2004) studied the population of whitefly; *B. tabaci* on cotton (*Gossypium hirsutum*) cultivar 76 in a growth chamber under $24 \pm 2^\circ\text{C}$ 65 ± 3 per cent relative humidity and 16 : 8 (light:dark) photoperiod and revealed that there were significant differences among population parameters in local parameters.

Aheer *et al.* (2006) studied the role of abiotic factors in population fluctuation of cotton sucking pests and reported that maximum temperature exerted significant and negative effect on jassids nymph in case of SLH-257. Minimum and average temperature and relative humidity showed positive and significant correlation with jassids adult with r values of 0.592, 0.532 and 0.581, respectively in case of NIAB-98. The effect of average temperature and rainfall was also significant and positive on jassids adult for RH-121 and SLH-257, respectively. All the abiotic factors when computed together exerted 18.7 and 6.4 per cent role in population fluctuation of

jassids nymph and adult, respectively.

Dhaka and Pareek (2008) reported that the incidence of jassids started from second and third week of June and reached to its peak (90/30 leaves) in the month of August. The incidence of whitefly started in the second and third week of June and reached to its peak in first week of October and remained throughout the growth period of the crop. The maximum temperature had negative significant and morning and evening RH showed positive significant effect on jassids population whereas the maximum temperature had positive significant and evening RH exerted negative significant effect on whitefly population.

Khan *et al.* (2008) observed incidence of pests is highly affected by weather factors like mean air temperature, relative humidity and rainfall. Correlations were developed between average population counts of cotton thrips, *Thrips tabaci* and red spider mite, *Tetranychus urticae* on eight genotypes of cotton at NIAB, Faisalabad under prevailing weather conditions and revealed that temperature played a significant and positive role for thrips ($r = 0.645$) but a negative one for red spider mite ($r = -0.510$). Relative humidity and rainfall were not correlated with mite population but positively associated with thrips population.

Mohapatra (2008) revealed that three major sucking pests i.e. leaf hopper, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* (Glover) and whitefly, *Bemisia tabaci* (Genn.) infested the crop from 30th standard metrological week to 50th standard metrological week. Peak population of *A. biguttula biguttula*, *B. tabaci* and *A. gossypii*

was attained during 41st standard metrological week, 44th standard metrological week and 35th standard metrological week. Among the weather parameters, temperature showed a positive correlation with *A. biguttula biguttula* and *A. gossypii*. The mean RH favoured the activity of *A. biguttula biguttula* and *A. gossypii*. Effect of rainfall was adverse on *A. gossypii* but was favourable for the activity of *A. biguttula biguttula*.

Nandihalli and Anitha (2008) studied the seasonal incidence of sucking pests in okra ecosystem and noticed that incidence of leaf hoppers, aphids and whiteflies commenced from April with 3.11, 6.01 and 9.16 leaf hoppers, aphids and whiteflies/3 leaves, respectively, while incidence of mites was commenced from 16th standard week (2.12 mites/3 leaves). Peak incidence of leaf hoppers, aphids, whiteflies and mite was noticed during last week of June (16.99 leaf hoppers/3 leaves) first week of April (14.91 whiteflies/3 leaves), second week of May (14.61 mites/3 leaves) and first week of July (27.17 aphids/3 leaves), respectively.

Prasad *et al.* (2008) conducted field experiment for five successive years from 2001-2002 to 2005-06 on population dynamics of cotton sucking pests at Regional Agricultural Research Station, Guntur. The appearance of aphids observed from 35th-37th standard week (September) during 2001 to 2003, while it was observed from 32th to 34th standard week (August) in succeeding years and peak incidence of aphids varied widely among various seasons from 33rd to 42nd standard week (mid-August to mid-January). The incidence of aphid had significant negative association with maximum temperature, minimum temperature, evening

relative humidity and rainfall and positive association with morning relative humidity. The total influence of all the weather parameters was low and non-significant on aphid population and the peak incidence of whiteflies was observed from 44th to 48th MW. Maximum and minimum temperature and rainfall were found to exert significant influence on whitefly population.

Daware *et al.* (2009) reported that the population of thrips started in second week of July (28th MW) and reached to peak in first week of August and observed upto second week of September (32nd-36th MW). They also found significant positive correlation between thrips population and minimum temperature and prolonged dry spell.

Dhawan *et al.* (2009) studied the population dynamics of key pests on *Bt* cotton and observed the highest number of whitefly (7.3, 1.9 and 2.9) in 35th MW in Mukstar, Ferozpur and Faridkot districts, respectively. Population dynamics of whitefly was negatively correlated with maximum, minimum and mean temperature in all the districts. In the Ferozpur district a positive correlation was found for whitefly with the maximum, minimum and mean temperature. Population dynamics of whitefly was negatively correlated with the morning RH and evening RH in all the districts.

Parasai and Shastry (2009) recorded incidence of aphids for two years which was maximum (35.1-45.7/3 leaves) during 33rd MW in first year and in second year it was maximum during (8.3-12.3/3 leaves) 37th MW. They also observed the increase in population of *chrysopa* and coccinellids from 30th – 50th MW during the incidence of

sucking pests.

Selvaraj *et al.* (2011) reported that maximum pest population (9.30/3 leaves) was noticed at temperature range from 21 to 31°C, relative humidity range from 82 and 55 per cent, zero rainfall, wind velocity 4.5 km h⁻¹, total sunshine hours (9.00 h week⁻¹), evaporation (56.10 mm) and dewfall (1.491 mm). The highest incidence of leafhopper population was recorded in MCU-7 followed by SPCH-22 and SVPR-3. Leafhopper population build up showed a significant and positive correlation with morning and evening relative humidity and rainfall, whereas it was significant and negative association with minimum temperature, wind velocity and dewfall.

Bhute *et al.* (2012) reported that seasonal incidence of major sucking insect pests of *Bt* cotton, aphids was highest (86.45 aphids/3 leaves) during 37th MW. Leafhoppers highest population (13.80 /3 leaves) was observed during 40th MW also thrips reached at highest incidence (110.10 thrips/3 leaves) in 40th MW.

The study conducted by Neelima *et al.* (2012) on DCH 32, Bunny *Bt* and non *Bt* cotton revealed that the cotton leafhopper, *Amrasca devastans* was active all throughout the season and has crossed ETL. Three peaks were observed during the season on all the three entries. Correlation studies between leafhopper population and weather parameters have shown a positive but non-significant relation with both maximum and minimum temperature and evening relative humidity; while, it was negative and non-significant with morning relative humidity and rainfall.

Shahid *et al.* (2012) studied the seasonal occurrence and activity of insect pests on cotton. Maximum thrips (carried $31 \pm 1.15/\text{leaf}$), mites population ($35.33 \pm 2.72/\text{leaf}$) was recorded. Abundant population of jassids ($3.33 \pm 0.33/\text{leaf}$) was noticed during October. In general three months *viz.*, May, June and July boosted thrips and mites population beyond the economic threshold level (ETL). Jassids and whiteflies population remained above ETL throughout observation period except during April when its activity was comparatively lower. It was concluded that last two weeks of June were the most favourable for thrips and mites population and whole month of August and September encouraged jassids population.

Shera (2012) noticed that the mean population of leafhopper nymphs was more in NCS 145 BG II as compared to RCH 134 *Bt* and MRC 6301 *Bt*. The peak population of leafhopper was recorded 90 days after sowing (DAS) in NCS 145 BG II (26.0/3 leaves), 100 DAS in RCH 134 *Bt* (19.8/3 leaves) and 110 DAS in MRC 6301 *Bt* (18.6/3 leaves).

2.2 Efficacy of insecticides as stem application against sucking pests of *Bt* cotton

According to Joshi (1989), monocrotophos 0.05% was the most effective treatment in controlling aphid, thrips and whitefly. The minimum number of whiteflies was observed in the plot treated with monocrotophos 0.05% and endosulfon 0.06% while the maximum number of aphids & whiteflies were observed in the plot treated with cypermethrin.

Elbert *et al.* (1990) revealed that some neonicotinoid group of insecticides i.e. imidacloprid,

thiamethoxam and acetamiprid basically launched for sucking pests as seed dresser and foliar spray. Imidacloprid was highly effective for control of sucking pests such as aphids, leaf hoppers, plant hoppers, thrips and whiteflies. It was also effective against Coleopteran, Lepidopteran and Dipteran pests.

Gohad and Katole (1991) showed that fenvalerate 0.02%, monocrotophos 0.05% and carbaryl 0.2% were significantly more effective against jassids.

Nagai *et al.* (1992) studied effectiveness & residues of chloropyriphos 250 a.i./ha, monocrotophos 175 a.i./ha, oxydemeton methyl 30 a.i./ha on sucking pest complex of cotton and concluded that monocrotophos and oxydemeton methyl controlled all three sucking pests.

Imidacloprid is a systemic and contact insecticide exhibiting low mammalian toxicity with primary activity against sucking insects such as aphids, leaf hoppers, plant hoppers, thrips and whiteflies and imidacloprid is especially appropriate for seed treatment and soil application (Mullins, 1993). However, the seed treatment with imidacloprid (Gaucho) 70 WS @ 7-10 g/kg seed effectively checked the aphid, jassid and thrips population up to 60 days after germination (Mote *et al.*, 1993).

Singh and Gupta (1993) reported that monocrotophos 500 a.i./ha, and endosulfon 750 a.i./ha were found most effective against jassids significantly upto 15-10 days, respectively.

Nauen and Elbert (1994) carried out laboratory and green house experiment on the effect of seed treatment with

imidacloprid on *Aphis gossypii* and *Myzus persicae* on cotton including behavioral electrophysiological agent scanning electron micrograph studies. It was observed that, the penetration capacity of *Myzus persicae* in the cellular environment is more than *Aphis gossypii* and this was the reason for the excellent control.

Mullins and Christie (1995) reported that the use of imidacloprid for the control of sucking pests of cotton and as spray of flowable formulations (Provado @ 1.6 lb a.i./gallon) was very effective against aphids and *Lygus spp.*

Mote *et al.* (1995) tested imidacloprid 70 WS as seed treatment @ 1 to 6% along with soil application of carbofuron 3G @ 1kg a.i./ha and two sprays of dimethoate 0.03% against initial sucking pests of cotton *viz.*, aphids, jassids and thrips. The result showed that amongst seed treatments, higher concentration i.e. 3, 4, 5 and 6% imidacloprid were highly effective against these pests. They suggested that imidacloprid 1% appeared to be optimum as a seed treatment for the control of initial sucking pests of cotton.

Joginder singh *et al.* (1996) observed that whiteflies population in plot treated with imidacloprid was below ETL & lesser than spray treatment and treatment can be effective against jassids.

A novel innovative technique of stem application of insecticide has been evolved at RARS, Lam, Guntur, (A.P.). This technique involves the application of chemicals to the main stem in one stroke (about 2-4 inches length depending on the age of the plant) with the help of camel hair brush. This

is very simple to practice as it involve only dipping of the brush in the chemical solution made by diluting with water and applying it on the main stem from 2-6 inches from the ground level. The result obtained for the control of the sucking pest like aphids, leafhopper and mealy bug is highly satisfactory, (Rao *et al.*, 1998).

Gaur *et al.* (1999) stated that for management of sucking pests on cotton where seed treatment is not done, stem application of monocrotophos (1:4 dilution) or imidacloprid 200 SL (1:20 dilution) using sms brush at 20, 40 and 60 DAS keeps the crop free from sucking pests upto 10 days without harming natural enemies.

Kumar *et al.* (1999) studied the comparative efficacy of acetamiprid along with monocrotophos and found that acetamiprid 20 SP @ 10 a.i./ha was superior in controlling the population of aphids and jassids upto 10 days after treatment.

Barkhade and Nimbalkar (2000) evolved a new technique "stem smearing" and new appliance TAGO (Treat and Go) for field application of systemic insecticides. It was found that monocrotophos **36 WSC 1 ml** + water **1 ml, 2 ml** and **3 ml** recorded **100** per cent reduction in the population of aphids.

Mohan and Katiyar (2000) reported that imidacloprid was the most effective insecticide in suppression of sucking pests and resulted in reduction of whitefly population.

Stem smearing in cotton with monocrotophos 36 WSC + water 1:1 registered maximum (88.07) per cent

reduction in aphids, followed by methyl demeton 25% + water 1:1 and monocrotophos 36 WSC with 1:2 dilution (Anonymous, 2002).

Singh *et al.* (2002) reported that acetamiprid 20 SP @ 0.010-0.015 kg/ha and imidacloprid 17.8 SL @ 0.020 kg/ha foliar spray were found significantly better in reducing jassids population than control.

According to Pawar *et al.* (2003) imidacloprid @ 17.8 a.i./ha and PI-011 @ 22.25g a.i./ha were equally effective against aphids and jassids on cotton.

Bheemanna and Patil (2003) have verified stem smearing technique for other insecticides *viz.*, dimethoate, methyl demeton and imidacloprid but the ratio of insecticide and water vary. The technology was found effective and recommended in Karnataka also.

Venugopal Rao *et al.* (2004) found that the stem application technique (monocrotophos 1:4 dilution or imidacloprid 1:20 dilution) at 20, 40, 60 days old crop is very effective against sucking pests of cotton.

Choudhary *et al.* (2005) conducted an experiment in which, three foliar sprays of imidacloprid (Confidor) 17.8 SL offered very good protection against sucking pests of cotton.

Nair (2006) studied the stem application in comparison with foliar spraying of systemic insecticide and found that stem application with monocrotophos or methyl demeton 1:4 or imidacloprid 200 SL in dilution with water at 20, 40 and 60 DAS or spraying monocrotophos 1.5ml/lit. or methyl demeton 2ml/lit. or imidacloprid 200 SL 0.2ml/lit. or acetamiprid 0.1g/lit. or thiamethoxam 0.2g/lit. or acephate

1.5g/lit. was also equally effective in controlling sucking pests.

Thakare *et al.* (2009) suggested that stem application of monocrotophos @ 1:4 dilution at 15, 30 and 45 DAE and imidacloprid @ 1:20 at 15, 30 and 45 DAE proved most economical, recording maximum yield and net profit.

Prasad *et al.* (2009) reported the stem application of monocrotophos (1:4 dilution) at 40 and 60 DAS as a prophylactic measure against sucking pest complex especially jassids and aphids.

Sitaramraju (2009) evaluated different insecticides *viz.*, monocrotophos 36% SL and acephate 75% SP @ 1:4 dilution, imidacloprid 70 WG, imidacloprid 17.8% SL 1:20 dilution and observed that monocrotophos 36% SL @ 1:4 dilution was most effective by reducing the leaf hopper population by >50% in all the post treatment counts i.e. 3 DAA (79%), 7 DAA (89%) and 10 DAA (55%). The treatments *viz.*, clothianidin 50% WG, 8% SL thiamethoxam 25% WG and imidacloprid recorded above 50% reduction at 7 DAA only. Least reduction was observed in acephate 75% SP @ 1:4 dilution. Thus, this technology has become an integral component of IPM module in several cotton growing states of India. Comparison of stem application technique vis-a-vis traditional technique in cotton with respect to amount of chemical required and total cost involved during the crop season.

AICRP-Cotton, Dharwad (2014) reported that Pesticide application technology of stem smearing of imidacloprid 200 SL (1.0 ml in 200 ml of water) reduced early sucking pests effectively.

AICRP-Cotton, Guntur (2014) reported that a cost effective technique of insecticide application to the main stem (stem application technique) of cotton plant at 20, 40 and 60 DAS has developed and found most effective against jassids and aphids. The significant technique is that it does not cause any harm to biological control agents which are the most important component of IPM.

AICRP-Cotton, Nandyal (2014) evaluated the ANGRAU model and compared with the Bio-intensive IPM module, Farmer method, ETL based plant protection and control. These modules include seed treatment with thiamethoxam, stem application with monocrotophos or imidacloprid at 40 and 60 DAS to manage aphids and jassids, pheromone trap for monitoring and growing of trap crops against *spodoptera litura* (Castor) and *Helicoverpa armigera* (Marigold).

Hole *et al.* (2014) suggested that the application of systemic insecticides such as oxydemeton methyl 25 EC or monocrotophos 36 EC with water in 1:4 proportion or imidacloprid 200 SL with water in 1:20 proportion at 30, 45 and 60 DAS were effective in controlling sucking pests.

2.3 Effect of stem application of insecticides on natural enemies of *Bt* cotton

Perusal of literature revealed that the references on stem application of insecticides against sucking pests in cotton are not available hence; references on spraying and seed treatment of insecticides against sucking pests in cotton are cited here.

Mizell and Sconyer (1992) studied the effect of

imidacloprid and thiamethoxam on population of lady bird beetle and found that imidacloprid had little impact on beneficial insects when used as foliar spray.

The seed treatment of imidacloprid increased the nitrogen and chlorophyll content of the cotton plants. Imidacloprid and thiamethoxam molecules contain five nitrogen atoms each; in addition, thiamethoxam contain one sulphur atom, being the major minor elements required for the growth of the plants. Higher the nitrogen and chlorophyll content in cotton plants, besides avoiding direct contact of seed dresser with predators, may probably the reasons for seed treatment being safer and conservative to these insect predators (Mote *et al.*, 1993).

Toda and Kashio (1997) reported that the imidacloprid was less toxic to *chrysopa* larvae among the 34 insecticides tested.

Satpute (1999) concluded that, seed treatment with imidacloprid and thiamethoxam were not only conservative to bioagents, but also attract more population of LBB adult and *chrysopa* eggs.

Katole and Patil (2000) noted that the seed treatment was safer than foliar spray. Imidacloprid @ 10g/kg seed treatment allowed maximum lady bird beetle adult and thiamethoxam 4 g/kg allowed maximum oviposition of *chrysopa spp.* and were at par with untreated control on cotton.

Choudhary *et al.* (2006) reveled that thiamethoxam 70 WS @ 4.28 g/kg seed and imidacloprid 600 FS @ 12 ml/kg seed recorded higher population of lady bird beetle and green

lacewing.

Patil *et al.* (2008) noticed higher predatory activity in untreated control, followed by imidacloprid 70 WS @ 4.9 g a.i./ha and thiamethoxam 3 g/kg at 15 days after spraying.

2.4 Yield and avoidable losses in cotton due to sucking pests

Vendramin and Nakana (1982) observed aphid as a serious pest during first 60 days, reducing the yield of seed cotton by 24.09 per cent and delaying the maturation.

According to Schwartz (1983), among the sucking pests, aphids alone are reported to cause about 19 per cent yield losses in cotton.

Sundaramurthy (1985) stated that cotton crop is attacked by large number of insect pests, including leaf hopper, whitefly and thrips that not only reduce the yield to the tune of 50-60 per cent but also adversely affect the quality of lint and seed.

Dhawan and Sidhu (1986) reported loss of 1.14 quintal of seed cotton per/ha due to attack of sucking pests.

Satpute *et al.* (1986) estimated the avoidable losses in cotton due to sucking pests and reported 8.65 per cent loss due to these pests attacking the crop during initial stage of plant growth.

Patil (1987) reported that sucking pests caused 22.85 per cent of avoidable yield losses. The maximum avoidable yield losses caused by both sucking pests and bollworms together were found to the extent of 29.17 per cent. The economic losses due to sucking pests were Rs. 810.90 per ha. Whereas, Dhawan *et al.* (1988), quoted the avoidable

losses due to sucking pests, mainly of jassids in upland cotton to the extent of 1.10 q/ha out of total yield of 10.48 q/ha. It was suggested that the saving resulted in net profit of Rs. 520 per hectare.

Satpute (1999) reported that 22.86 per cent yield losses can be avoided by protecting the cotton crop from sucking pests and Badrinarayanan (2002) reported that *Bt* cotton still need control of other (non lepidopteran) pests like sucking pests attacking the crop in early stage.

Five major sucking insect pests have been reported to damage the crop out of which aphids and jassids are the most important ones which infest the crop at early stage and cause heavy losses (Choudhary and Garg, 2002). Whereas, in an experiment conducted to assess avoidable losses due to major pests of cotton, avoidable losses due to all the major pests collectively was estimated to the tune of 41.82 per cent out of which 8.37 per cent was due to sucking pests (Banerjee, 2002).

Dhawan *et al.* (2008) reported that RCH 134 recorded higher avoidable yield loss to the extent of 4.1, 6.5 and 8.8 per cent, when chemically protected against sucking pests. Ferozepur district observed higher avoidable yield loss to the tune of 3.7, 6.3 and 7.8 per cent due to attack of sucking pests, followed by Mansa and Bathinda districts. The avoidable yield losses in Punjab due to both sucking pests and tobacco caterpillar were observed to be 3.2, 5.4 and 7.6%, respectively.

Murugesan and Kavitha (2010) reported that incidence of the leafhopper; *Amrasca devastans* (Distant) in

cotton has been prevalent from vegetative to reproductive phase of crop growth. The loss in seed cotton yield due to leaf hopper is accounted to 330-390 kg ha⁻¹.

Shera (2012) noticed that the extent of avoidable losses were 252 kg/ha (11.9%) in MRC 6301 *Bt* as against 263 kg/ha (11.2%) in RCH 134 *Bt* and 290 kg/ha (16.2%) in NCS 145 BG II. The increase in yield due to control of sucking pests resulted in net profit of Rs 6224, 5916 and 6160/ha with a cost benefit ratio of 1:5.7, 1:5.4 and 1:4.2 in RCH 134 *Bt*, MRC 6301 *Bt* and NCS 145 BG II, respectively.

3. MATERIAL AND METHODS

The present investigation entitled “Bioefficacy of insecticides against sucking pests of *Bt* cotton as stem

application” was carried out at the experimental farm of All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra during *Kharif* 2014. The study was carried out to findout effectiveness of insecticides for management of sucking pests. The materials and methods employed for these studies are described in this chapter.

3.1 MATERIAL

3.1.1 Seed

The untreated seeds of cotton hybrid “RCH 2 *Bt*” were made available through the All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist-Ahmednagar.

3.1.2 Equipments

The materials consisted of various agriculture equipments required for preparatory tillage, sowing and intercultural operation, smearing bottle, measuring cylinder, weighing balance with weights, manures and fertilizers, measuring tape, pegs, tags *etc.* were used from Department of Entomology, PGI, MPKV, Rahuri.

3.1.3 Insecticides

The insecticides were supplied by Department of Entomology, M.P.K.V., Rahuri. The details of chemical insecticides tested for the experiment with their common name, formulation and source are given in Table 1.

3.2 METHODS

3.2.1 Seasonal incidence of sucking pests in *Bt* cotton

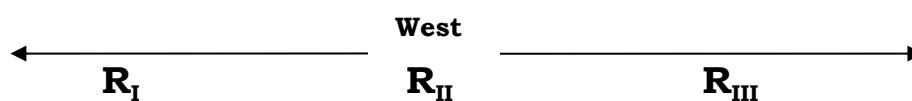
3.2.1.1 Experimental details

Design : Non-replicated
 Plot size : 500 sq. m. (25 m x 20 m)
 Spacing : 90 cm x 90 cm
 Hybrid : RCH 2 *Bt*
 Sowing date : 28.5.2014

3.2.2 Bioefficacy of insecticides against sucking pests of *Bt* cotton

3.2.2.1 Details of experiment

Design : Randomized Block Design (RBD)
 Replication : Three
 Treatments : Eight
 Plot size : 7.2 x 5.4 m²
 Total no. of plots : 24
 No. of plants/plot : 48
 Variety : RCH 2 *Bt*
 Spacing : 90 cm x 90 cm
 Season : *Kharif* 2014
 Date of sowing : May 28th, 2014
 Application date : 1st Application, July 1th, 2014
 2nd Application, July 17th, 2014
 3rd Application, August 2nd, 2014.



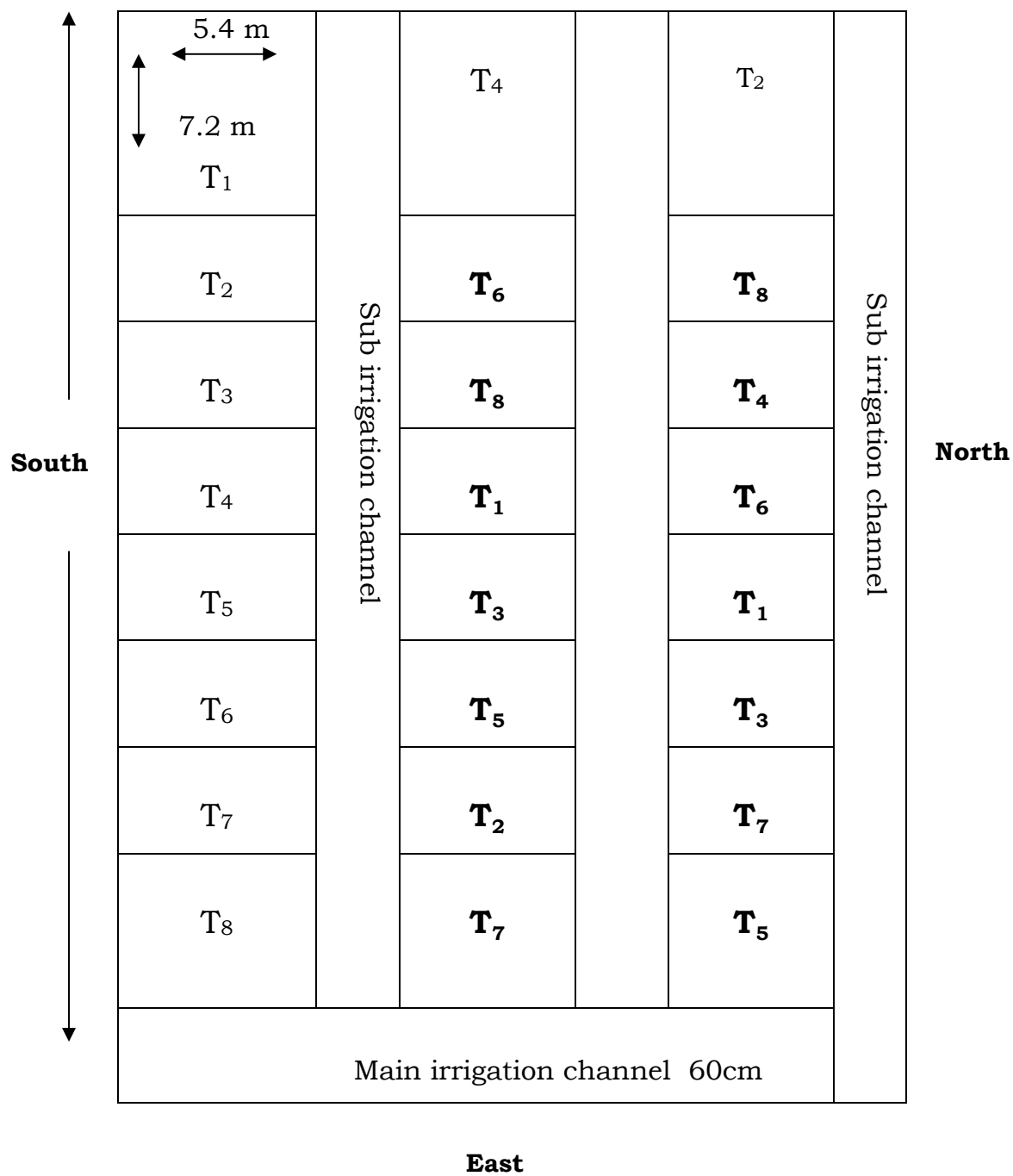


Fig.1. Plan of layout

Table1. Details of chemical insecticides used in the study

Sr. No	Name of Insecticides		Group	Chemical Name	Source
	Common Name	Trade Name			
1	Imidacloprid 17.8 SL	Tatamida	Neonicotinoids	1-(6-chloro-3 pyridinyl methyl) N-nitro-2-imidazolinimie	Rallis Company
2	Oxydemeton methyl 25 EC	Metasystox	Oganophosphate	S-[2-(ethyl sulfinyl) ethyl] O,O-dimethyl phosphorothioate	United phosphorous Limited
3	Monocrotophos 36 SL	Monocil	Oganophosphate	Dimethyl phosphate of 3 hydroxy-N-methyl-cis crotonamide	Inseciticide (India) Limited
4	Profenophos 50 EC	Curacron	Oganophosphate	0-4- bromo-2-chlorophynyl 0-ethyl S-propyl phosphorothioate	Syngenta
5	Carbosulfan 25 EC	Marshal	Carbamate	2,3-Dihydro-2,2-dimethyl-7-benzofuranyl [(dibutylamino)thio] methyl carbamate	Sinoharvest Agrochemicals
6	Dimethoate 30 EC	Tagfor	Oganophosphate	0-0-[dimethyl-5-(N-methyl carbamoyl methyl) phosphoro-dithoate]	Rallis Company
7	Malathion 50 EC	Salmathion	Oganophosphate	Diethyl 2 [(dimethoxyphosphorothioyl) sulfanyl] butanedioate	Sulphur mills Limited

3.2.2.2 Treatment details

The experiment comprises of eight treatments *viz.*, imidacloprid 17.8 SL, oxydemeton methyl 25 EC, monocrotophos 36 SL, profenophos 50 EC, carbosulfan 25 EC, dimethoate 30 EC, malathion 50 EC and untreated control. The details of the treatments are given in table 2.

Table 2. Treatment details

Sr. No	Treatment details	Formulation	Dose
1	Imidacloprid	17.8 SL	1:20 dilution
2	Oxydemeton methyl	25 EC	1:4 dilution
3	Monocrotophos	36 EC	1:4 dilution
4	Profenophos	50 EC	1:4 dilution
5	Carbosulfan	25 EC	1:4 dilution
6	Dimethoate	30 EC	1:4 dilution
7	Malathion	50 EC	1:4 dilution
8	Untreated Control	-----	-----

3.2.2.3 Raising of cotton crop

Cotton seeds of RCH 2 *Bt* cotton hybrid were sown in bed prepared in field. Irrigation was given at an interval of 6-7 days. Inter-culturing operations were carried out as and when required.

3.2.2.4 Preparing insecticidal solution

The requirement of insecticidal solution per plot was calculated by applying untreated control plot with water

then the requisite quantity of respective insecticide was mixed in required quantity of water.

3.2.2.5 Application of insecticides

The insecticidal solution was applied with hand to the main stem in one stroke above 4-5 inches from the ground level using the smearing bottle. The insecticidal solution for each treatment was prepared by mixing insecticide as specified in treatment details. Totally three applications were given. First application was given at 30 days after sowing and subsequent applications were applied at fortnightly interval.

3.3 Method of recording observations

3.3.1 Seasonal incidence of sucking pests in *Bt* cotton

Observations on incidence of sucking pests were recorded weekly from 5 randomly selected plants along with weather parameters.

3.3.2 Bioefficacy of insecticides against sucking pests of *Bt* cotton

The efficacy of insecticides were evaluated by selecting five plants randomly from each plot for recording the observation on number of sucking pests per three leaves (Top, middle and bottom) of cotton one day before first application and 5, 10 and 15 days after each application.

3.3.3 Impact on Natural enemies

Average numbers of natural enemies were counted on five randomly selected plants from each treatment plot one day before first application and 7 days after each application.

3.3.4 Yield

Weight of seed cotton during each picking was taken from each plot. The treatment wise total yield was calculated by summation of the yield obtained from each picking. The yield data were expressed as q/ha.

3.4 Statistical analysis

The experimental data were subjected to statistical analysis as per the method of statistical analysis of randomized block design. The per cent values were converted to arcsin transformation and insect number was converted into square root transformed value ($\sqrt{x+0.5}$) and subjected to statistical analysis.

4. RESULT AND DISCUSSION

The present investigation entitled “Bioefficacy of insecticides against sucking pests of *Bt* cotton as stem application” was carried out at the experimental farm of All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra during *Kharif* 2014. The experiments were carried out to study the seasonal incidence of sucking pests and effectiveness of insecticides for management of sucking pests along with their effect on natural enemies of *Bt* cotton. The results are presented herewith under different headings and subheadings.

4.1 Seasonal incidence of sucking pests in *Bt* cotton

Observations on seasonal incidence of sucking pests of *Bt* cotton were recorded at an interval of seven days; starting from 28-05-2014 (22nd MW) to 20-11-2014 (47th MW), on five plants at five randomly selected spots along with weather parameters.

4.1.1 Aphids

Observations on seasonal incidence of aphids infesting *Bt* cotton were recorded at weekly interval by taking count of aphids on top, middle and bottom leaves. The data are presented in table 3 and graphically depicted in Fig. 2 & 3.

The incidence of aphids per 3 leaves ranged from 1.15 to 80.77. The maximum population was recorded in 40th MW. Thereafter, the aphids population was found decreasing upto November. The climatic condition during preceding week was 20.3°C, 33.6°C, 70.4%, 40.7% and zero mm (T_{min} , T_{max} ,

Table 3. Relationship between weather parameters and sucking pests of *Bt* cotton

Standard MW	Aphids/ 3 leaves	Jassids/ 3 leaves	Thrips/ 3 leaves	Whiteflies / 3 leaves	Predator/ plant	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
						Maximum	Minimum	Morning	Evening	
June 24	0.00	1.77	0.00	0.00	0.00	36.7	26.1	65.1	35.9	18.8
25	1.15	2.07	0.00	1.92	1.09	33.4	24.7	66.1	46.4	22.4
26	3.19	6.39	15.65	2.69	2.25	35.9	22.5	65.7	35.6	0.0
July 27	31.99	8.10	19.13	9.30	5.43	34.4	23.3	71.7	51.9	11.8
28	36.10	9.75	27.47	12.25	8.24	32.7	23.4	73.4	51.9	16.8
29	51.79	10.40	30.38	14.33	10.47	30.8	24.0	71.7	64.0	0.0
30	54.43	11.18	32.28	15.76	11.90	29.1	22.3	76.3	62.9	22.8
Aug 31	57.88	12.00	35.20	17.80	14.28	29.0	22.6	74.9	68.6	13.2
32	60.90	14.95	49.46	18.01	17.06	30.5	21.9	72.4	57.0	1.6
33	63.61	2.98	43.64	19.39	18.23	31.8	21.9	70.6	50.6	34
34	68.89	9.60	50.51	15.23	19.08	32.7	22.6	78.9	51.3	44.4
35	14.29	9.16	47.54	27.16	5.84	28.6	21.8	81.6	72.4	129.9
Sept.36	41.73	8.48	2.12	23.83	9.21	29.2	22.2	75.0	66.3	15.8
37	45.74	10.58	7.63	27.77	12.56	30.7	21.0	70.9	56.9	0
38	33.98	6.68	5.55	19.25	11.39	31.9	21.0	71.4	51.6	4
39	71.89	11.14	4.65	25.03	15.69	33.6	20.3	70.4	40.7	0
Oct. 40	80.77	6.29	6.30	20.04	19.48	34.1	22.2	70.1	40.1	0
41	76.81	5.98	1.41	23.44	13.83	34.0	19.6	64.0	33.0	7.4
42	28.26	6.08	14.93	22.00	10.12	33.7	21.0	72.1	43.6	13.4
43	35.56	7.30	16.56	25.89	10.53	29.4	16.1	72.6	57.0	0
Nov. 44	31.88	7.41	18.26	29.19	8.26	32.0	14.0	55.7	36.1	0.0
45	25.87	1.82	8.90	26.62	5.37	31.8	15.9	57.6	37.4	0.0
46	14.57	2.08	8.38	18.81	3.72	29.7	20.1	80.7	63.1	96.2
47	9.85	2.45	7.95	7.82	2.14	29.8	15.1	69.4	41.0	0.0
Correlation Coefficient	Aphids					-0.10	0.02	0.14	0.08	-0.24
	Jassids					-0.32	0.19	0.38	0.48**	-0.11
	Thrips					-0.36	0.16	0.45**	0.49**	0.36
	Whiteflies					-0.48*	-0.54**	0.03	0.21	0.09
	Predator					-0.15	0.02	0.23	0.14	-0.17

RH-I, RH-II and rainfall), respectively. The positive correlation was found to exist between aphids incidence and metrological parameters ($T_{\min}=0.02$, RH-I=0.14, RH-II=0.08) except $T_{\max}$ i.e -0.10 and Rainfall=-0.24.

The present findings with regard to correlation of weather parameters with aphids population are in line with Mohapatra (2008), who found that among the weather parameters, temperature showed the positive correlation with aphids, *Aphis gossypii* and effect of rainfall was adverse. Hence it is not possible to compare the present results with the previous one with regard to the population build up of aphids.

4.1.2 Jassids

Data on (Table 3 and Fig.2 & 3) incidence of jassids during experimental period was found to range from 1.77 to 14.95 jassids per 3 leaves. The maximum population was noticed in 32th MW. Thereafter, the pest activity slowly decreased upto 47th MW.

The temperature, humidity and rainfall during preceding week and the peak activity period of jassids were found in the range of 22.6 to 29.0°C, 74.9 to 68.6% and 13.2mm, respectively. The data on correlation coefficient between pest and weather parameters are presented in table 3. The results revealed that the jassids population was found negatively correlated with $T_{\max}=-0.32$ and Rainfall=-0.11; while positively correlated with $T_{\min}=0.19$ and RH-I=0.38 and RH-II=0.48, respectively. However, highly significant positive correlation was found with RH-II=0.48.

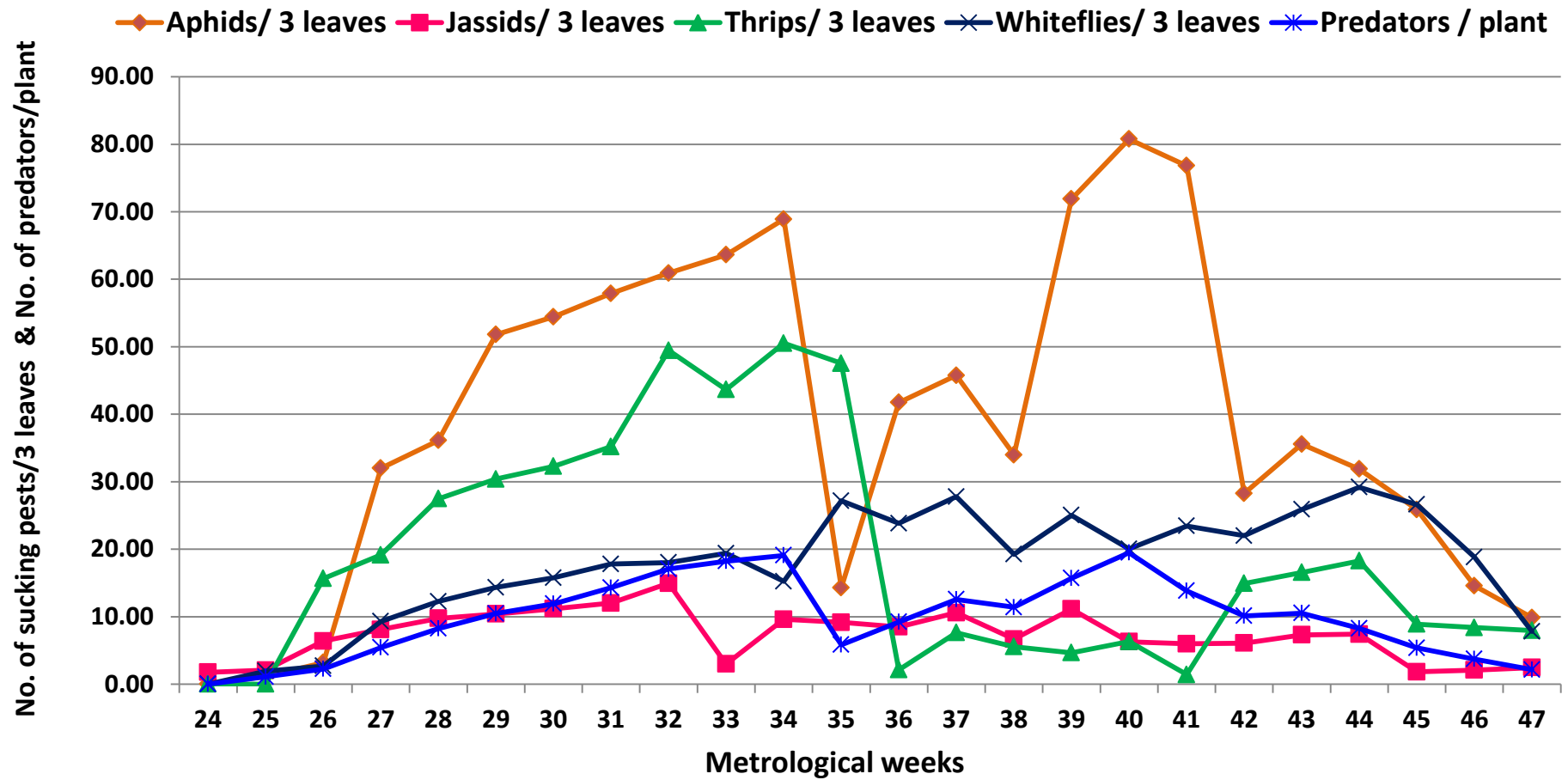


Fig-2. Population dynamics of sucking pests and its natural enemies in *Bt* cotton

The present findings are in conformity with those of Gupta *et al.* (1997), Dhaka and Pareek (2008) and Shera (2012). The incidence of jassids was recorded during the last week of July to mid-September (24.8-32.6°C), Gupta *et al.*, (1997). Dhaka and Pareek (2008) reported that the incidence of jassids started from second and third week of June and reached to its peak in the month of August and maximum temperature had negative significant and relative humidity (RH-I and RH-II) showed positive significant effect on jassids. Shera (2012) reported that the peak population of the leafhopper was recorded 90-110 days after sowing (DAS) in various cotton hybrids.

4.1.3 Thrips

The population dynamics of thrips was studied by taking count of thrips population during 24th to 47th MW. The data are presented in table 3 and graphically depicted in Fig.2 & 3.

The incidence of thrips during experimental period ranged from 1.41 to 50.51 thrips per 3 leaves. The peak incidence of thrips was found in 34th MW during this period, temperature of preceding week was 21.9 to 31.8°C, humidity 70.6 to 50.6% with 34mm rainfall. It could be seen that thrips population was found positively correlated with $T_{\min}$ (0.16) and Rainfall (0.36); while negatively correlated with $T_{\max}$ (-0.36). However, highly significant positive correlation was found with relative humidity (RH-I=0.45 and RH-II=0.49).

The present investigation regarding the seasonal incidence of thrips on cotton is in line with the findings of Gupta *et al.* (1997), Kudale (2000) and Khan *et al.* (2008).

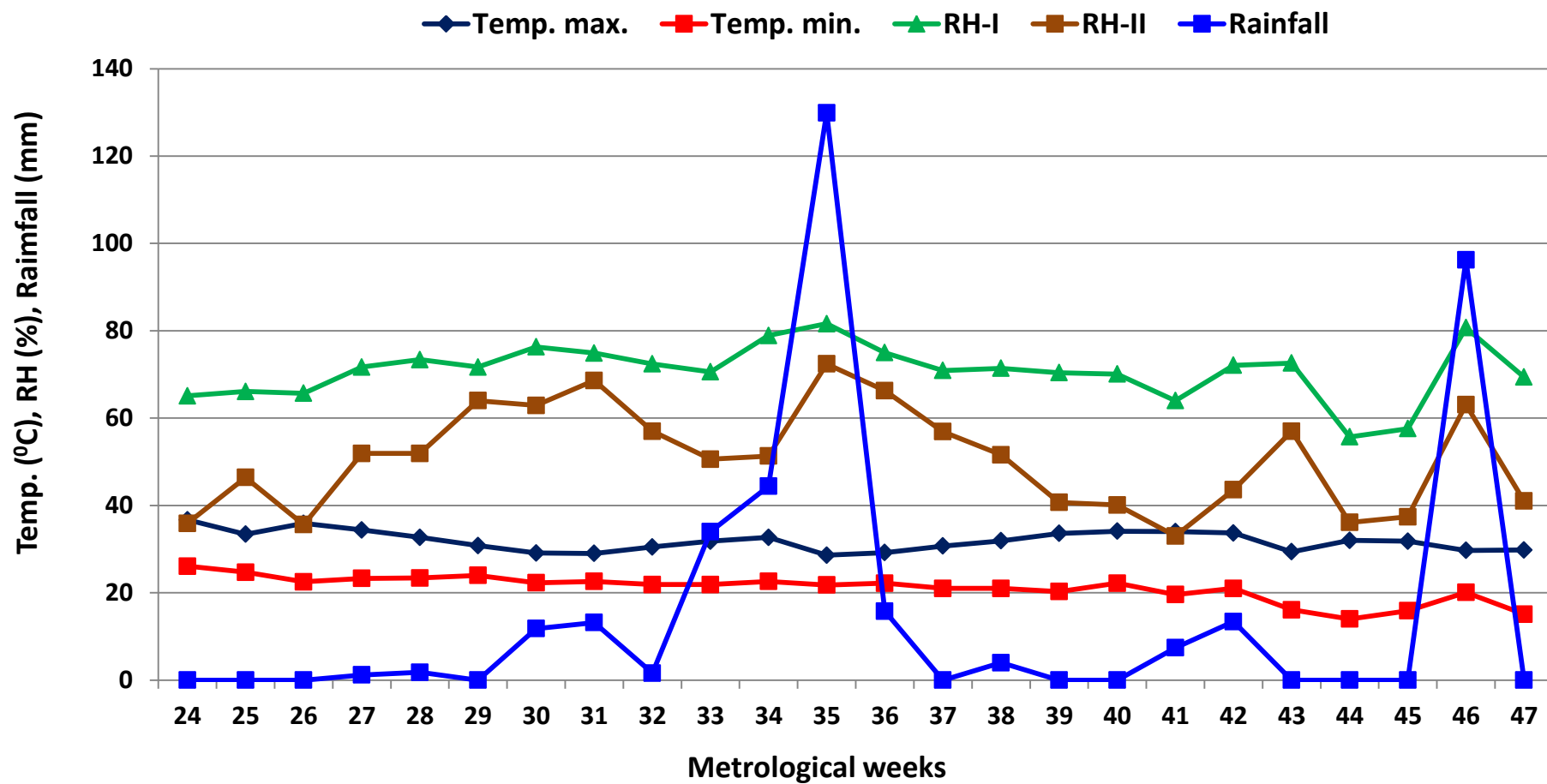


Fig-3. Metrological parameters during the experimental period

Gupta *et al.* (1997) noticed the incidence at four week stage of crop. The peak population of thrips was recorded during second fortnight of August to first fortnight of October (30°C and 74-85% RH). Kudale (2000) reported that there was significant correlation between thrips population and maximum temperature and morning relative humidity. Khan *et al.* (2008) studied that the relative humidity and rainfall were positively correlated with thrips population.

4.1.4 Whiteflies

Population dynamics of whiteflies on *Bt* cotton hybrids was studied by recording whiteflies per 3 leaves. The data are presented in table 3 and depicted graphically in Fig.2 & 3. In general the pest activity was observed highest in 44th MW. The incidence of whiteflies during experimental period ranged from 1.92 to 29.19 whiteflies per 3 leaves. After the peak activity, the population was found decreasing. The climatic conditions during the 43rd MW in respect of T_{min} , T_{max} , RH-I, RH-II and Rainfall recorded were 16.1°C, 29.4°C, 72.6 to 57.0% and zero mm, respectively.

The data on correlation coefficient are presented in table 3. During the studies, the whiteflies population was highly significant and negatively correlated with temperature (T_{max} =-0.48 and T_{min} =-0.54), while positively correlated with relative humidity (RH-I and RH-II) and rainfall i.e. 0.03, 0.21 and 0.09, respectively.

The present findings with regard to correlation of weather parameters with whiteflies population are in line with Mohapatra (2008) and Prasad *et al.* (2008). Mohapatra (2008) revealed that the peak incidence of whitefly *Bemisia tabaci* was

attained during 44th MW. Among the weather parameters, temperature showed negative correlation with whiteflies *Bemisia tabaci*. Prasad *et al.* (2008) in his experiment at Guntur, he observed that the peak incidence was observed from 44th to 48th MW.

4.1.5 Natural enemies

The population dynamics of predators was studied by taking count of predators population. The data are presented in table 3 and graphically depicted in Fig.2 & 3.

It is observed that activity of predators was found in the range of 1.09 to 19.48 per plant. The maximum population was observed in 40th MW. Thereafter, the pest activity slowly decreased upto November. Weather parameters during previous week of peak activity, were found to range i.e. temperature 22.2 to 34.1°C, relative humidity 70.1 to 40.1% with zero mm rainfall.

It could be seen that natural enemies population was found to be negatively correlated with maximum temperature (-0.15) and rainfall (-0.17) while positively correlated with minimum temperature (0.02), morning and evening relative humidity (0.23 and 0.14), respectively.

The present findings with regard to correlation of weather parameter with natural enemies are in line with Parasai and Shastry (2009) who observed the increase in population of *chrysopa* and coccinellids from 30th-50th MW during the highest incidence of sucking pests. However no mentions have been made by these workers about the correlation and weather parameters. Hence, it is not possible to compare the present results with the previous ones with

regards to the population build up and correlation with weather parameters.

4.2 Bioefficacy of insecticides as stem application against sucking pests

The observations on the mean pest survival population in the various pesticidal treatments after each of the three stem application of insecticides in the trial conducted at All India Coordinated Cotton Improvement Project, MPKV, Rahuri (Ahmednagar) are presented in Table 4 to 7. Pre-treatment count was taken one day before and post-treatment counts were taken 5, 10 and 15 days after each stem application of insecticides. The data were subjected to square root transformation for counts before the analysis of variance.

4.2.1 Bioefficacy of insecticides as stem application against aphids

The efficacy of various pesticides given in table 2 under field conditions was judged on the basis of average number of aphids per 3 leaves present on five randomly selected and tagged plants one day before and 5, 10 and 15 days after the application of insecticides.

4.2.1.1 Incidence of aphids on cotton before first application

The data on average number of aphids recorded one day before first application of insecticides under the head pre-treatment count are presented in table 4.

The data presented in table 4 showed that average number of aphids one day before the application of insecticides varied from 30.27 to 32.13 per 3 leaves. The incidence of aphids taken one day before the application of

insecticides were statistically non-significant at 5% level of significance, suggesting that the incidence of aphids on cotton was uniform; while before second and third application of insecticides they were significant indicating the incidence of aphids was not uniform.

4.2.1.2 First application of insecticides given on 1-07-2014

4.2.1.2.1 Five days after first application

The data on average number of surviving aphids population are presented in table 4. It is evident from the data that the average number of aphids five days after first application varied from 22.10 to 34.83 aphids per 3 leaves in various treatments. All the insecticidal treatments were found to be significantly superior over untreated control in reducing pest incidence. The minimum infestation of aphids was seen with monocrotophos 36 SL @ 1:4 dilution and it was found significantly superior to all other treatments except oxydemeton methyl 25 EC @ 1:4 dilution; which was at par with this treatment. This was followed by carbosulfan 25 EC @ 1:4 dilution, imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum aphids population (30.23 aphids/3 leaves) amongst the treated plots was observed in profenophos 50 EC @ 1:4 dilution and it was found significantly inferior amongst the pesticides tested.

4.2.1.2.2 Ten days after first application

It is observed from the data given table 4 that, all the pesticidal treatments were significantly superior over untreated control in reducing the aphids population, which was found to vary from 11.03 to 40.03 aphids per 3 leaves in

Table 4: Bioefficacy of insecticides as stem application against aphids

Sr. No	Treatment	Dose	Number of Aphids / 3 leaves																
			Pre-count	1 st application				2 nd application				3 rd application				Average of 3 applications			
				5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean
1	Imidacloprid 17.8 SL	1:20	30.40 (5.56)*	24.73 (5.02)	13.60 (3.75)	16.77 (4.15)	18.37 (4.34)	12.83 (3.65)	7.07 (2.75)	8.67 (3.03)	9.52 (3.17)	6.63 (2.67)	3.63 (2.03)	4.50 (2.24)	4.92 (2.33)	14.73 (3.90)	8.10 (2.93)	9.98 (3.24)	10.94 (3.38)
2	Oxydemeton methyl 25 EC	1:4	31.53 (5.66)	22.63 (4.81)	11.50 (3.46)	13.60 (3.75)	15.91 (4.05)	10.07 (3.25)	5.13 (2.37)	6.07 (2.56)	7.09 (2.75)	4.50 (2.24)	2.27 (1.66)	2.70 (1.79)	3.16 (1.91)	12.40 (3.59)	6.30 (2.61)	7.46 (2.82)	8.72 (3.04)
3	Monocrotophos 36 SL	1:4	31.73 (5.68)	22.10 (4.75)	11.03 (3.40)	12.70 (3.63)	15.28 (3.97)	9.27 (3.12)	4.60 (2.26)	5.30 (2.41)	6.39 (2.62)	3.87 (2.09)	1.93 (1.56)	2.23 (1.65)	2.68 (1.78)	11.74 (3.50)	5.86 (2.52)	6.74 (2.69)	8.11 (2.93)
4	Profenophos 50 EC	1:4	31.13 (5.62)	30.23 (5.54)	28.73 (5.40)	37.33 (6.15)	32.10 (5.71)	36.47 (6.08)	34.70 (5.93)	45.03 (6.74)	38.73 (6.26)	44.00 (6.67)	41.80 (6.50)	54.33 (7.40)	46.71 (6.87)	36.90 (6.11)	35.08 (5.96)	45.57 (6.78)	39.18 (6.30)
5	Carbosulfan 25 EC	1:4	31.27 (5.63)	23.93 (4.94)	12.43 (3.60)	14.93 (3.93)	17.10 (4.19)	11.20 (3.42)	5.83 (2.52)	7.00 (2.74)	8.01 (2.92)	5.27 (2.40)	2.77 (1.81)	3.27 (1.94)	3.77 (2.07)	13.47 (3.74)	7.01 (2.74)	8.40 (2.98)	9.63 (3.18)
6	Dimethoate 30 EC	1:4	32.13 (5.71)	27.67 (5.30)	24.90 (5.04)	31.13 (5.62)	27.90 (5.33)	29.37 (5.46)	26.47 (5.19)	33.07 (5.79)	29.63 (5.49)	31.20 (5.63)	28.10 (5.34)	35.10 (5.96)	31.47 (5.65)	29.41 (5.47)	26.49 (5.19)	33.10 (5.79)	29.67 (5.49)
7	Malathion 50 EC	1:4	30.87 (5.60)	29.63 (5.49)	27.57 (5.30)	35.00 (5.96)	30.73 (5.59)	34.23 (5.89)	31.80 (5.68)	40.40 (6.39)	35.48 (6.00)	39.50 (6.32)	36.70 (6.10)	46.63 (6.86)	40.94 (6.44)	34.46 (5.91)	32.02 (5.70)	40.68 (6.42)	35.72 (6.02)
8	Untreated Control	-----	30.27 (5.55)	34.83 (5.94)	40.03 (6.36)	46.13 (6.82)	40.33 (6.39)	49.57 (7.07)	53.30 (7.32)	57.37 (7.59)	53.41 (7.34)	59.53 (7.73)	61.80 (7.88)	64.17 (8.03)	61.83 (7.88)	47.98 (6.96)	51.71 (7.22)	55.89 (7.51)	51.86 (7.23)
	SE $\pm$		0.06	0.06	0.07	0.10	0.08	0.11	0.13	0.15	0.13	0.14	0.13	0.12	0.13	0.10	0.11	0.12	0.11
	CD at 5%		NS	0.18	0.21	0.31	0.23	0.35	0.39	0.45	0.39	0.42	0.39	0.37	0.39	0.31	0.33	0.34	0.34
	CV%		1.71	14.09	12.91	14.03	13.65	14.25	16.09	16.27	15.53	13.59	11.45	17.89	14.31	13.95	13.48	16.06	14.23

* Figures in the parentheses are ($\sqrt{x+0.5}$) transformations, DAA- Days after application

various treatments. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all others. Oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution were next in their efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest incidence. The maximum aphids population amongst the treated plots was again observed in profenophos 50 EC @ 1:4 dilution, which was significantly inferior than others except malathion 50 EC @ 1:4 dilution.

4.2.1.2.3 Fifteen days after first application

It is observed from the data presented in table 4 that, fifteen days after application of insecticides, the aphids population was found to range from 12.70 to 46.13 aphids per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy, were at par with each other and were significantly superior over the remaining treatments. The maximum aphids population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution; which was significantly inferior over all treatments except malathion 50 EC @ 1:4 dilution.

4.2.1.2.4 Average of first application

The data of pooled means of aphids population recorded on 5, 10 and 15 days after application of insecticides

presented in table 4 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the aphids population amongst the pesticides tested. Monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with it in reducing the pest incidence. Amongst the remaining treatments, imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best and followed by dimethoate 30 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment amongst the pesticides tested right from the beginning, recording the maximum aphids population at all the time intervals.

4.2.1.3 Second application of insecticides given on 17-07-2014

4.2.1.3.1 Five days after second application

The observations (Table 4) recorded five days after the application of the pesticides revealed significant superiority of pesticides in reducing the pest population, over the untreated control. Among the insecticides, monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to rest of the pesticidal treatments. Oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution were the next best treatments in reducing the pest population and it was followed by imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC and malathion 50 EC @ 1:4 dilution. Among the treated plots significantly maximum population of aphids was found in profenophos 50EC @ 1:4 dilution.

4.2.1.3.2 Ten days after second application

It is observed from the data given table 4 that, all

the pesticidal treatments were significantly superior over untreated control in reducing the aphids population, which was found to vary from 4.60 to 53.30 aphids per 3 leaves in various treatments. Significantly lowest population of aphids was again recorded in monocrotophos 36 SL @ 1:4 dilution than all other treatments, including oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were next best and also at par with each other in efficacy. The efficacy of insecticides in decreasing order of efficacy are carbosulfan 25 EC @ 1:4 dilution, imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. The maximum aphid population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution.

4.2.1.3.3 Fifteen days after second application

Fifteen days after application, the average population of aphids was found to range from 5.30 to 57.37 aphids per 3 leaves in various (Table 4) pesticidal treatments. The pesticidal treatments were significantly superior over untreated control in reducing the pest population. However, significant differences were found to exist amongst all the pesticidal treatments. Monocrotophos 36 SL @ 1:4 dilution was found to be the most effective, while profenophos 50 EC @ 1:4 dilution was least effective. The efficacy of various pesticides in reducing the pest population was in the order of: monocrotophos 36 SL > oxydemeton methyl 25 EC > carbosulfan 25 EC > imidacloprid 17.8 SL > dimethoate 30 EC > malathion 50 EC and profenophos 50 EC.

4.2.1.3.4 Average of second application

The data of pooled means of aphids population recorded on 5, 10 and 15 days after application of insecticides presented in table 4 revealed that among the pesticidal treatments monocrotophos 36 SL @ 1:4 dilution has appeared as the significantly superior treatment over others, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par. Next in the efficacy were imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. The maximum aphid population was recorded in profenophos 50 EC @ 1:4 dilution, suggesting its least efficacy in controlling the pest.

4.2.1.4 Third application of insecticides given on 2-08-2014

4.2.1.4.1 Five days after third application

The data on average surviving aphids population recorded five days after third application are presented in table 4. It is evident from the data that the average number of aphids five days after application varied from 3.87 to 59.53 aphids per 3 leaves in various treatments. All the insecticidal treatments were significantly superior over untreated control in reducing pest incidence. The minimum infestation of aphids was seen in plot treated with monocrotophos 36 SL @ 1:4 dilution and thus, it was found significantly superior to all other treatments except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with this treatment and were followed by imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum aphid population among the

treated plot was observed in profenophos 50 EC @ 1:4 dilution (44 aphids/3 leaves) and it was found significantly inferior among the pesticides tested except malathion 50 EC @ 1:4 dilution.

4.2.1.4.2 Ten days after third application

It is observed from the data given in table 4 that, all the pesticidal treatments were significantly superior over untreated control in reducing the aphids population, which was found to vary from 1.93 to 61.80 aphids per 3 leaves in various treatments. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all others. Oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution were next in efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest incidence. The maximum aphid population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution, which was significantly inferior among all other treatments.

4.2.1.4.3 Fifteen days after third application

It is observed from the data presented in table 4 that, 15 days after application of insecticides the aphids population was found to range from 2.23 to 64.17 aphids per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was observed in plot treated with monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution, which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy and were at par with each other and were

significantly superior over the remaining treatments. The maximum aphid population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution which was significantly inferior in all treatments.

4.2.1.4.4 Average of third application

The data of pooled means of aphids population recorded on 5, 10 and 15 days after application of insecticides presented in table 4 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the aphids population. Among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with it in reducing the pest incidence. Among the remaining treatments, imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best and followed by dimethoate 30 EC and malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning recording the maximum aphids population at all the time intervals.

4.2.1.5 Average of three applications of insecticides against aphids population

The data on pooled means population build up of aphids recorded at 5, 10 and 15 days after each application of insecticides given in table 4 revealed that all the pesticidal treatments were significantly superior over the untreated control in reducing the incidence of pest. Monocrotophos 36 SL @ 1:4 dilution has emerged as significantly superior over rest of the pesticidal treatments except oxydemeton methyl 25

EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par in reducing the pest population. The next promising treatments were imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best followed by dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Malathion 50 EC and profenophos 50 EC @ 1:4 dilution were statistically at par with each other, while the profenophos 50 EC @ 1:4 dilution was least effective in controlling the pest population.

4.2.1.6 Comparison of present findings with the previous work

The present findings are in conformity with those of Gaur *et al.* (1999), Barkhade and Nimbalkar (2000) and Hole *et al.* (2014). Gaur *et al.* (1999) reported that stem application of monocrotophos (1:4 dilution) or imidacloprid 200 SL (1:20 dilution) using sms brush at 20, 40 and 60 DAS keeps the crop free from sucking pests upto 10 days without harming natural enemies. Barkhade and Nimbalkar (2000) found that monocrotophos 36 WSC 1 ml + water 1 ml, 2 ml and 3 ml recorded 100 per cent reduction in the population of aphids. Hole *et al.* (2014) suggested that the application of systemic insecticides such as oxydemeton methyl 25 EC or monocrotophos 36 EC with water in 1:4 proportion or imidacloprid 200 SL with water in 1:20 proportion at 30, 45 and 60 DAS were effective in controlling sucking pests.

4.2.2 Bioefficacy of insecticides as stem application against jassids

The efficacy of various pesticides given in table 2 under field conditions was judged on the basis of observations recorded on the average number of jassids per 3 leaves

present on five randomly selected and tagged plants one day before and 5, 10 and 15 days after the application of insecticides.

4.2.2.1 Incidence of jassids on cotton before first application

The data on average number of jassids recorded one day before first application of insecticides under the head pre-treatment count are presented in table 5.

The data presented in table 5 showed that average number of jassids one day before the first, second and third application of insecticides varied from 5.87 to 7.20 per 3 leaves. These observations on incidence of jassids taken one day before the first application of insecticides were statistically significant at 5% level of significance, suggesting that the incidence of jassids on cotton was not uniform.

4.2.2.2 First application of insecticides given on 1-07-2014

4.2.2.2.1 Five days after first application

The data on average surviving jassids population recorded five days after first application are presented in table 5. It is evident from the data that the average number of jassids five days after application varied from 4.90 to 7.67 jassids per 3 leaves in various treatments. All the insecticidal treatments were significantly superior over untreated control in reducing pest incidence. Monocrotophos 36 SL @ 1:4 dilution has showed lowest incidence of jassids, which was significantly superior to all other treatments followed by oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution. The maximum jassids population among the treated plots (6.70 jassids/3

leaves) was observed in profenophos 50 EC @ 1:4 dilution and it was found significantly inferior among the pesticides tested except malathion 50 EC @ 1:4 dilution.

4.2.2.2.2 Ten days after first application

It is observed from the data given table 5 that all the pesticidal treatments were significantly superior over untreated control in reducing the jassids population, which was found to vary from 2.47 to 8.77 jassids per 3 leaves. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all other treatments in reducing pest incidence, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution. The maximum jassids population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution, which was significantly inferior except Malathion 50 EC @ 1:4 dilution.

4.2.2.2.3 Fifteen days after first application

The data presented in table 5 indicate that 15 days after application of insecticides, the average number of jassids population was found to vary from 2.83 to 10.17 jassids per 3 leaves. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest and the highest population were observed in plot treated with monocrotophos 36 SL and profenophos 50 EC @ 1:4 dilution, respectively. Monocrotophos 36 SL @ 1:4 dilution was significantly superior in reducing jassid population, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy and were at par with it. Maximum jassids population among the treated plots was observed in

Table 5: Bioefficacy of insecticides as stem application against jassids

Sr No	Treatment	Dose	Number of jassids / 3 leaves																
			Pre-Count	1 st application				2 nd application				3 rd application				Average of 3 applications			
				5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean
1	Imidacloprid 17.8 SL	1:20	7.20 (2.77)*	5.30 (2.41)	2.90 (1.84)	3.57 (2.02)	3.92 (2.10)	2.73 (1.80)	1.47 (1.40)	1.87 (1.54)	2.02 (1.59)	1.40 (1.38)	0.80 (1.14)	0.97 (1.21)	1.06 (1.21)	3.14 (1.91)	1.72 (1.49)	2.13 (1.62)	2.33 (1.68)
2	Oxydemeton methyl 25 EC	1:4	6.93 (2.73)	5.10 (2.37)	2.60 (1.76)	3.07 (1.89)	3.59 (2.02)	2.27 (1.66)	1.17 (1.29)	1.37 (1.37)	1.60 (1.45)	1.00 (1.22)	0.50 (1.00)	0.60 (1.05)	0.70 (1.10)	2.79 (1.81)	1.42 (1.39)	1.68 (1.48)	1.96 (1.57)
3	Monocrotophos 36 SL	1:4	6.87 (2.71)	4.90 (2.32)	2.47 (1.72)	2.83 (1.83)	3.40 (1.97)	2.07 (1.60)	1.00 (1.22)	1.17 (1.29)	1.41 (1.38)	0.87 (1.17)	0.40 (0.95)	0.50 (1.00)	0.59 (1.04)	2.61 (1.76)	1.29 (1.34)	1.50 (1.41)	1.80 (1.52)
4	Profenophos 50 EC	1:4	6.73 (2.69)	6.70 (2.68)	6.33 (2.61)	8.23 (2.95)	7.09 (2.75)	8.07 (2.92)	7.67 (2.85)	9.97 (3.23)	8.57 (3.01)	9.73 (3.20)	9.23 (3.12)	12.00 (3.53)	10.32 (3.29)	8.17 (2.94)	7.74 (2.87)	10.07 (3.25)	8.66 (3.03)
5	Carbosulfan 25 EC	1:4	5.87 (2.52)	5.17 (2.38)	2.70 (1.79)	3.20 (1.92)	3.69 (2.05)	2.43 (1.71)	1.27 (1.33)	1.53 (1.43)	1.74 (1.50)	1.13 (1.28)	0.60 (1.05)	0.70 (1.10)	0.81 (1.15)	2.91 (1.85)	1.52 (1.42)	1.81 (1.52)	2.08 (1.61)
6	Dimethoate 30 EC	1:4	6.73 (2.69)	5.47 (2.44)	4.93 (2.33)	6.17 (2.58)	5.52 (2.45)	5.83 (2.52)	5.23 (2.39)	6.53 (2.65)	5.87 (2.52)	6.20 (2.59)	5.57 (2.46)	6.90 (2.72)	6.22 (2.59)	5.83 (2.52)	5.24 (2.40)	6.53 (2.65)	5.87 (2.52)
7	Malathion 50 EC	1:4	7.20 (2.77)	6.27 (2.60)	5.80 (2.51)	7.40 (2.81)	6.49 (2.64)	7.20 (2.77)	6.70 (2.68)	8.53 (3.00)	7.48 (2.82)	8.30 (2.97)	7.73 (2.87)	9.80 (3.21)	8.61 (3.02)	7.26 (2.78)	6.74 (2.69)	8.58 (3.01)	7.53 (2.83)
8	Untreated Control	-----	6.67 (2.68)	7.67 (2.86)	8.77 (3.04)	10.17 (3.26)	8.87 (3.06)	10.87 (3.37)	11.67 (3.49)	12.53 (3.61)	11.69 (3.49)	13.03 (3.68)	13.53 (3.74)	14.03 (3.81)	13.53 (3.75)	10.52 (3.32)	11.32 (3.44)	12.24 (3.57)	11.36 (3.44)
	SE $\pm$		0.04	0.03	0.04	0.05	0.04	0.05	0.05	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	CD at 5%		0.12	0.09	0.11	0.15	0.11	0.16	0.16	0.19	0.17	0.18	0.16	0.16	0.16	0.14	0.14	0.16	0.14
	CV%		10.29	14.08	10.44	11.41	11.97	12.39	14.53	12.62	13.18	11.86	13.34	12.49	12.56	12.77	12.77	12.17	12.57

* Figures in the parentheses are ($\sqrt{x+0.5}$) transformations, DAA- Days after application

profenophos 50 EC @ 1:4 dilution which was significantly inferior over all treatments except malathion 50 EC @ 1:4 dilution.

4.2.2.2.4 Average of first application

The data of pooled means of jassids population recorded on 5, 10 and 15 days after application of insecticides presented in table 5, revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the jassids population. Among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution which were at par with it in reducing the pest incidence. Amongst the remaining treatments, dimethoate 30 EC @ 1:4 dilution appeared as the next best treatment. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning, recording the maximum jassids population at all the time intervals.

4.2.2.3 Second application of insecticides given on 17-07-2014

4.2.2.3.1 Five days after second application

The observations (Table 5) recorded five days after second application revealed the superiority of pesticides in reducing pest population which was found to vary from 2.07 to 10.87 jassids per 3 leaves over untreated control. Among the pesticides, the minimum infestation of jassids was seen in monocrotophos 36 SL @ 1:4 dilution and thus it was found significantly superior to all other treatments except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4

dilution which were at par with this treatment. Among the treated plots, significantly higher jassids population was observed in plot treated with profenophos 50 EC @ 1:4 dilution.

4.2.2.3.2 Ten days after second application

It is observed from the data given in table 5 that all the pesticidal treatments were significantly superior over untreated control in reducing the jassids population, which was found to vary from 1.00 to 11.67 jassids per 3 leaves. Significantly lowest population of jassids was again recorded in monocrotophos 36 SL @ 1:4 dilution followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which they were at par in reducing pest population. The maximum jassids population among treated plots was again observed in profenophos 50EC @ 1:4 dilution, which was significantly inferior to all the treatments.

4.2.2.3.3 Fifteen days after second application

Fifteen days after application of insecticides the jassids population was found to range from 1.17 to 12.53 jassids per 3 leaves (Table 5). The pesticidal treatments were significantly superior over untreated control in reducing the pest population. Monocrotophos 36 SL @ 1:4 dilution was most effective in reducing the pest population than all other treatments except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par. While profenophos 50 EC @ 1:4 dilution recorded the maximum jassids population (9.97 jassids/3 leaves) among the treated plots.

4.2.2.3.4 Average of second application

The data of pooled means of jassids population recorded on 5, 10 and 15 days after application of insecticides presented in table 5 revealed that among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was significantly superior over others except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par in reducing the pest incidence. Among the remaining treatments imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best, followed by dimethoate 30 EC and malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution found to be significantly inferior among the pesticides right from the beginning recording the maximum jassids population at all the time intervals.

4.2.2.4 Third application of insecticides given on 2-08-2014

4.2.1.4.1 Five days after third application

Jassids population ranging from 0.87 to 13.03 jassids per 3 leaves in various treatments five days after third application (Table 5) was found to be significantly less in all the pesticidal treatments than untreated control. Monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior in reducing jassids population than all others, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par and were followed by, imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum jassids population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution (9.73 jassids/3

leaves) and it was found significantly inferior among the pesticides tested.

4.2.2.4.2 Ten days after third application

It is observed from the data given in table 5 that all the pesticidal treatments were significantly superior over untreated control in reducing the jassids population, which was found to vary from 0.40 to 13.53 jassids per 3 leaves. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all others. Oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution were next in efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest population. Maximum jassids population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution, which was significantly inferior to others.

4.2.2.4.3 Fifteen days after third application

It is observed from the data presented in table 5 that, fifteen days after application of insecticides, the jassids population was found to range from 0.50 to 14.03 jassids per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution. Maximum jassids population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution which is significantly inferior over all other treatments.

4.2.2.4.4 Average of third application

The data of pooled means of jassids population recorded on 5, 10 and 15 days after application of insecticides presented in table 5 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the jassids population. Among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with it in reducing the pest population. Among the remaining treatments, imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best followed by dimethoate 30 EC and malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning, recording the highest jassids population at all the time intervals.

4.2.2.5 Average of three applications of insecticides against jassids population

The data on pooled means of population build up of jassids recorded at 5, 10 and 15 days after each application of insecticides given in table 5 revealed that all the pesticidal treatments were significantly superior over the untreated control in reducing the incidence of pest. Monocrotophos 36 SL @ 1:4 dilution has emerged as the significantly superior treatment over rest of the pesticides in reducing the pest population except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it. The next promising treatments were imidacloprid 17.8 SL @ 1:20 dilution followed by dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Malathion 50 EC and profenophos 50 EC @ 1:4 dilution were statistically at par with

each other; while the profenophos 50 EC @ 1:4 dilution treatment was observed to be the least effective in controlling the pest population.

4.2.2.6 Comparison of present findings with the previous work

The present findings are in line with Bheemanna and Patil (2003), Prasad *et al.* (2009) and Sitaramraju (2009). Bheemanna and Patil (2003) have verified stem smearing technique for other insecticides *viz.*, dimethoate, methyl demeton, imidacloprid and revealed that stem smearing was effective in controlling sucking pests *viz.*, aphids, jassids, thrips and whiteflies. Prasad *et al.* (2009) reported the effectiveness of stem application of monocrotophos (1:4 dilution) at 40 and 60 DAS as a prophylactic measure against sucking pest complex especially jassids and aphids. Sitaramraju (2009) reported that monocrotophos 36 SL @ 1:4 dilution was most effective in reducing the leaf hopper population by >50% in all the post treatment counts i.e. 3 DAA (79%), 7 DAA (89%) and 10 DAA (55%).

4.2.3 Bioefficacy of insecticides as stem application against thrips

The efficacy of various pesticides given in table 2 under field conditions was judged on the basis of observations recorded on the average number of thrips per 3 leaves present on five randomly selected and tagged plants one day before and 5, 10 and 15 days after the application of insecticides.

4.2.3.1 Incidence of thrips on cotton before first application

The data on average number of thrips recorded one day before first application of insecticides under the head pre-

treatment count are presented in table 6.

The data presented in table 6 showed that average number of thrips one day before the first application of insecticides varied from 18.60 to 19.80 per 3 leaves. These observations on incidence of thrips taken one day before the first application of insecticides were statistically non-significant at 5% level of significance, suggesting that the incidence of thrips on cotton was uniform; while before second and third application of insecticides they were significant indicating the incidence of thrips is not uniform.

4.2.3.2 First application of insecticides given on 1-07-2014

4.2.3.2.1 Five days after first application

The data on average number of surviving thrips population recorded five days after first application are presented in table 6. It is evident from the data that average number of thrips five days after application varied from 13.87 to 21.67 thrips per 3 leaves in various treatments. All the insecticidal treatments were significantly superior over untreated control in reducing pest incidence. The minimum infestation of thrips was seen in monocrotophos 36 SL @ 1:4 dilution and thus it was found significantly superior to all other treatments except oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution which were at par with this treatment followed by, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum thrips population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution (18.10 thrips/3 leaves) and it was found significantly

inferior among pesticides tested except dimethoate 30 EC and malathion 50 EC @ 1:4 dilution.

4.2.3.2.2 Ten days after first application

It is observed from the data given in table 6 that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population, which was found to vary from 6.93 to 24.63 thrips per 3 leaves in various treatments. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all others. Oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution were next in efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest population. The maximum thrips population (17.20 thrips/3 leaves) among treated plots was again observed in profenophos 50 EC @ 1:4 dilution, which was significantly more inferior than others except dimethoate 30 EC and malathion 50 EC @ 1:4 dilution.

4.2.3.2.3 Fifteen days after first application

It is observed from the data presented in table 6 that, fifteen days after application of insecticides the thrips population was found to range from 7.97 to 28.40 thrips per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy

Table 6: Bioefficacy of insecticides as stem application against thrips

Sr. no	Treatment	Dose	Number of thrips / 3 leaves																
			Pre-count	1 st application				2 nd application				3 rd application				Average of 3 applications			
				5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean
1	Imidacloprid 17.8 SL	1:20	19.13 (4.43)*	14.83 (3.92)	8.20 (2.95)	10.07 (3.25)	11.03 (3.40)	7.70 (2.86)	4.27 (2.18)	5.20 (2.39)	5.72 (2.49)	4.00 (2.12)	2.20 (1.64)	2.70 (1.79)	2.97 (1.86)	8.84 (3.06)	4.89 (2.32)	5.99 (2.55)	6.57 (2.66)
2	Oxydemeton methyl 25 EC	1:4	19.80 (4.51)	14.10 (3.82)	7.20 (2.77)	8.05 (3.00)	9.93 (3.23)	6.27 (2.60)	3.20 (1.92)	3.77 (2.07)	4.41 (2.22)	2.77 (1.81)	1.40 (1.38)	1.70 (1.48)	1.96 (1.57)	7.71 (2.87)	3.93 (2.11)	4.66 (2.27)	5.43 (2.44)
3	Monocrotophos 36 SL	1:4	18.67 (4.38)	13.87 (3.79)	6.93 (2.73)	7.97 (2.91)	9.59 (3.18)	5.80 (2.51)	2.90 (1.84)	3.33 (1.96)	4.01 (2.12)	2.40 (1.70)	1.23 (1.32)	1.37 (1.37)	1.67 (1.47)	7.36 (2.80)	3.69 (2.05)	4.22 (2.17)	5.09 (2.36)
4	Profenophos 50 EC	1:4	19.40 (4.46)	18.10 (4.31)	17.20 (4.20)	22.37 (4.78)	19.22 (4.44)	21.87 (4.73)	20.77 (4.61)	26.97 (5.24)	23.20 (4.87)	26.37 (5.18)	25.03 (5.05)	32.53 (5.74)	27.98 (5.34)	22.11 (4.76)	21.00 (4.64)	27.29 (5.27)	23.47 (4.90)
5	Carbosulfan 25 EC	1:4	19.20 (4.44)	14.63 (3.89)	7.63 (2.85)	9.13 (3.10)	10.47 (3.31)	6.87 (2.71)	3.57 (2.02)	4.30 (2.19)	4.91 (2.33)	3.27 (1.94)	1.70 (1.48)	2.00 (1.58)	2.32 (1.68)	8.26 (2.96)	4.30 (2.19)	5.14 (2.38)	5.90 (2.53)
6	Dimethoate 30 EC	1:4	19.27 (4.44)	16.87 (4.17)	15.20 (3.96)	18.97 (4.41)	17.01 (4.18)	17.93 (4.29)	16.10 (4.07)	20.13 (4.54)	18.06 (4.32)	19.00 (4.41)	17.13 (4.20)	21.40 (4.68)	19.18 (4.44)	17.93 (4.29)	16.14 (4.08)	20.17 (4.55)	18.08 (4.31)
7	Malathion 50 EC	1:4	18.73 (4.38)	17.77 (4.27)	16.53 (4.12)	20.97 (4.63)	18.42 (4.35)	20.50 (4.58)	19.07 (4.42)	24.20 (4.97)	21.26 (4.66)	23.67 (4.91)	22.00 (4.74)	27.93 (5.33)	24.53 (5.00)	20.64 (4.60)	19.20 (4.44)	24.37 (4.99)	21.40 (4.68)
8	Untreated Control	-----	18.60 (4.37)	21.67 (4.71)	24.63 (5.01)	28.40 (5.37)	24.90 (5.04)	30.53 (5.56)	32.80 (5.76)	35.27 (5.96)	32.87 (5.78)	36.63 (6.08)	37.97 (6.19)	39.40 (6.31)	38.00 (6.20)	29.61 (5.49)	31.80 (5.68)	34.63 (5.90)	31.92 (5.69)
	SE ±		0.06	0.07	0.08	0.11	0.08	0.12	0.12	0.14	0.12	0.13	0.12	0.12	0.12	0.10	0.11	0.12	0.11
	CD at 5%		--	0.21	0.25	0.33	0.26	0.35	0.37	0.41	0.38	0.39	0.37	0.36	0.37	0.31	0.33	0.36	0.34
	CV%		12.49	11.98	14.25	13.22	13.15	15.48	16.38	13.98	15.28	15.83	17.72	17.45	17.01	14.43	16.11	14.88	15.14

* Figures in the parentheses are ($\sqrt{x+0.5}$) transformations, DAA- Days after application

and were at par with each other and were significantly superior over the remaining treatments. Maximum thrips population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution which is significantly inferior over all other treatments.

4.2.3.2.4 Average of first application

The data of pooled means of thrips population recorded on 5, 10 and 15 days after application of insecticides presented in table 6 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population among the pesticides tested. Monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution which were at par with it in reducing the pest population. Among the remaining treatments, dimethoate 30 EC @ 1:4 dilution appeared as the next best followed by malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning, recording the maximum thrips population at all the time intervals.

4.2.3.3 Second application of insecticides given on 17-07-2014

4.2.1.3.1 Five days after second application

The observations (Table 6) recorded five days after application of insecticides revealed significant superiority of pesticides in reducing the pest population over the untreated control. Monocrotophos 36 SL @ 1:4 dilution was significantly superior to rest of the pesticides except oxydemeton methyl 25

EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution which were at par with this treatment. Among the treated plots significantly maximum population of thrips was found in profenophos 50 EC @ 1:4 dilution.

4.2.3.3.2 Ten days after second application

It is observed from the data given in table 6 that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population, which was found to vary from 2.90 to 32.80 thrips per 3 leaves. Significantly lowest population of thrips was again recorded in monocrotophos 36 SL @ 1:4 dilution followed by oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution. Maximum thrips population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution which was significantly inferior than other treatments.

4.2.3.3.3 Fifteen days after second application

Fifteen days after application of insecticides the average population of thrips was found to range from 3.33 to 35.27 thrips per 3 leaves (Table 6). All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy and were at par with each other and were significantly superior over the remaining treatments. Maximum thrips population among the treated plots was

observed in profenophos 50 EC @ 1:4 dilution which is significantly inferior over all other treatments except malathion 50 EC @ 1:4 dilution.

4.2.3.3.4 Average of second application

The data of pooled means of thrips population recorded on 5, 10 and 15 days after application of insecticides presented in table 6 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population. Monocrotophos 36 SL @ 1:4 dilution appeared as the significantly superior treatment over others, except oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution which were at par with it in reducing the pest incidence. Maximum thrips population was recorded in profenophos 50 EC @ 1:4 dilution suggesting its least efficacy in controlling the pest.

4.2.3.4 Third application of insecticides given on 2-08-2014

4.2.1.4.1 Five days after third application

The data on average surviving thrips population recorded five days after third application are presented in table 6. It is evident from the data that the average number of thrips five days after application varied from 2.40 to 36.63 thrips per 3 leaves. All the insecticidal treatments were significantly superior over untreated control in reducing pest incidence. Minimum infestation of thrips was seen in monocrotophos 36 SL @ 1:4 dilution and thus, it was found significantly superior to all other treatments except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with this treatment and were followed by imidacloprid 17.8 SL @ 1:20 dilution, dimethoate

30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum thrips population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution (26.37 thrips/3 leaves) and it was found significantly inferior amongst the pesticides tested except malathion 50 EC @ 1:4 dilution.

4.2.3.4.2 Ten days after third application

It is observed from the data given in table 6 that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population, which was found to vary from 1.23 to 37.97 thrips per 3 leaves in various treatments. Monocrotophos 36 SL @ 1:4 dilution emerged as the significantly superior treatment to all others. Oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution were next in efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest incidence. Maximum thrips population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution which was significantly inferior to others except malathion 50 EC @ 1:4 dilution.

4.2.3.4.3 Fifteen days after third application

Thrips population fifteen days after application of insecticides (Table 6) ranged from 1.37 to 39.40 thrips per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lower and higher thrips population was observed in monocrotophos 36 SL and profenophos 50 EC @ 1:4 dilution. Oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution were next in efficacy to monocrotophos 36

SL @ 1:4 dilution and the maximum thrips population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution, which is significantly inferior over all other treatments.

4.2.3.4.4 Average of third application

The data of pooled means of thrips population recorded on 5, 10 and 15 days after application of insecticides presented in table 6 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the thrips population among the pesticides tested. Monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it in reducing the pest incidence. Maximum thrips population was recorded in profenophos 50 EC @ 1:4 dilution, thereby suggesting its least efficacy in controlling the pest. However, this treatment was found to be at par with malathion 50 EC @ 1:4 dilution.

4.2.3.5 Average of three applications of insecticides against thrips population

The data on pooled means of population build up of thrips recorded at 5, 10 and 15 days after each of application of insecticides given in table 6 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the incidence of pest. Monocrotophos 36 SL @ 1:4 dilution was significantly superior to the rest, except oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:4 dilution; with which it was at par in reducing the pest population. Maximum population of

thrips was again observed in profenophos 50 EC @ 1:4 dilution which was at par with malathion 50 EC @ 1:4 dilution.

4.2.3.6 Comparison of present findings with the previous work

The present findings are in consonance with Venugopal Rao *et al.* (2004), Nair (2006) and Hole *et al.* (2014). Venugopal Rao *et al.* (2004) found that the stem application technique (monocrotophos 1:4 dilution or imidacloprid 1:20 dilution) at 20, 40, 60 days old crop is very effective against sucking pests of cotton. Nair (2006) found that stem application with monocrotophos or methyl demeton 1:4 or imidacloprid 200 SL in dilution with water at 20, 40 and 60 DAS was effective in controlling the sucking pest. Hole *et al.* (2014) suggested that the application of systemic insecticides such as oxydemeton methyl 25 EC or monocrotophos 36 EC with water in 1:4 proportion or imidacloprid 200 SL with water in 1:20 proportion at 30, 45 and 60 DAS were effective in controlling the sucking pests.

4.2.4 Bioefficacy of insecticides as stem application against whiteflies

The efficacy of various pesticides given in table 2 under field conditions was judged on the basis of observations recorded on the average number of whiteflies per 3 leaves present on five randomly selected and tagged plants one day before and 5, 10 and 15 days after the application of insecticides.

4.2.4.1 Incidence of whiteflies on cotton before first application

The data on average number of whiteflies recorded one day before first application of insecticides are presented in table 7.

The data presented in table 7 showed that average number of whiteflies one day before the first application of insecticides varied from 8.27 to 9.20. These observations on incidence of whiteflies taken one day before the first application of insecticides were statistically significant at 5% level of significance suggesting that the incidence of whiteflies on cotton was not uniform.

4.2.4.2 First application of insecticides given on 1-07-2014

4.2.1.2.1 Five days after first application

The data on average population of whiteflies recorded five days after first application are presented in table 7. It is evident from the data that average number of whiteflies five days after application varied from 6.27 to 10.23 whiteflies per 3 leaves in various treatments. All the insecticidal treatments were significantly superior over untreated control in reducing the pest incidence. Monocrotophos 36 SL @ 1:4 dilution showed lowest incidence of whiteflies and thus it was found significantly superior to all other treatments except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it. Imidacloprid 17.8 SL @ 1:20 dilution was found to be significantly superior to all other remaining pesticides in reducing the pest population. In efficacy, imidacloprid 17.8 SL @ 1:20 dilution was followed by dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @

1:4 dilution. Maximum whiteflies population among treated plots was observed in profenophos 50 EC @ 1:4 dilution and was found to be significantly inferior among the pesticides tested.

4.2.4.2.2 Ten days after first application

It is observed from the data given table 7 that, all the pesticidal treatments were significantly superior over untreated control in reducing the whiteflies population, which was found to vary from 3.13 to 11.73 whiteflies per 3 leaves in various treatments. The lowest incidence was observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment to all others except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par. Maximum whiteflies population among treated plots was again observed in profenophos 50 EC @ 1:4 dilution treated plot, which was significantly inferior to others.

4.2.4.2.3 Fifteen days after first application

The data presented in table 7 indicated that, fifteen days after application of insecticides the whiteflies population was found to range from 3.60 to 13.53 whiteflies per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. Monocrotophos 36 SL @ 1:4 dilution has emerged as the significantly superior treatment, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy and were at par with each other and were significantly superior over the remaining treatments. While

Table 7: Bioefficacy of insecticides as stem application against whiteflies

Sr. no	Treatment	Dose	Number of whiteflies / 3 leaves																
			Pre-count	1 st application				2 nd application				3 rd application				Average of 3 applications			
				5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean	5 DAA	10 DAA	15 DAA	Mean
1	Imidacloprid 17.8 SL	1:20	9.07 (3.09)*	6.93 (2.73)	3.80 (2.07)	4.70 (2.28)	5.14 (2.38)	3.60 (2.02)	1.97 (1.57)	2.43 (1.71)	2.67 (1.78)	1.87 (1.54)	1.00 (1.22)	1.27 (1.33)	1.38 (1.37)	4.13 (2.15)	2.26 (1.66)	2.80 (1.82)	3.06 (1.89)
2	Oxydemeton methyl 25 EC	1:4	8.87 (3.06)	6.53 (2.65)	3.33 (1.96)	3.93 (2.11)	4.60 (2.26)	2.90 (1.84)	1.47 (1.40)	1.73 (1.49)	2.03 (1.59)	1.30 (1.34)	0.67 (1.08)	0.77 (1.13)	0.91 (1.19)	3.58 (2.02)	1.82 (1.52)	2.14 (1.63)	2.51 (1.74)
3	Monocrotophos 36 SL	1:4	9.13 (3.10)	6.27 (2.60)	3.13 (1.91)	3.60 (2.02)	4.33 (2.20)	2.60 (1.76)	1.33 (1.35)	1.50 (1.41)	1.81 (1.52)	1.07 (1.25)	0.57 (1.03)	0.67 (1.08)	0.77 (1.13)	3.31 (1.95)	1.68 (1.48)	2.04 (1.59)	2.34 (1.69)
4	Profenophos 50 EC	1:4	8.27 (2.96)	8.63 (3.02)	8.23 (2.95)	10.67 (3.34)	9.18 (3.11)	10.43 (3.31)	9.90 (3.22)	12.87 (3.66)	11.07 (3.40)	12.60 (3.62)	11.97 (3.53)	15.53 (4.00)	13.37 (3.72)	10.56 (3.32)	10.03 (3.25)	12.94 (3.67))	11.18 (3.42)
5	Carbosulfan 25 EC	1:4	8.80 (3.05)	6.63 (2.67)	3.47 (1.99)	4.13 (2.15)	4.74 (2.29)	3.10 (1.90)	1.63 (1.46)	1.97 (1.57)	2.23 (1.65)	1.47 (1.40)	0.77 (1.13)	0.93 (1.20)	1.06 (1.25)	3.73 (2.06)	1.96 (1.57)	2.34 (1.69)	2.68 (1.78)
6	Dimethoate 30 EC	1:4	9.20 (3.11)	7.87 (2.89)	7.07 (2.75)	8.80 (3.05)	7.91 (2.90)	8.33 (2.97)	7.50 (2.83)	9.37 (3.14)	8.40 (2.98)	8.80 (3.05)	7.97 (2.91)	9.90 (3.22)	8.89 (3.06)	8.33 (2.97)	7.51 (2.83)	9.36 (3.14)	8.40 (2.98)
7	Malathion 50 EC	1:4	8.47 (2.99)	8.00 (2.92)	7.40 (2.81)	9.43 (3.15)	8.28 (2.96)	9.23 (3.12)	8.57 (3.01)	10.90 (3.38)	9.57 (3.17)	10.60 (3.33)	9.90 (3.22)	12.57 (3.61)	11.02 (3.39)	9.28 (3.13)	8.62 (3.02)	10.97 (3.39)	9.62 (3.18)
8	Untreated Control	-----	8.87 (3.06)	10.23 (3.28)	11.73 (3.50)	13.53 (3.74)	11.83 (3.51)	14.53 (3.87)	15.63 (4.01)	16.77 (4.14)	15.64 (4.02)	17.43 (4.23)	18.10 (4.31)	18.80 (4.39)	18.11 (4.31)	14.07 (3.82)	15.16 (3.96)	16.37 (4.11)	15.20 (3.96)
	SE ±		0.02	0.03	0.04	0.05	0.04	0.06	0.07	0.08	0.07	0.07	0.07	0.06	0.06	0.05	0.06	0.06	0.06
	CD at 5%		0.07	0.08	0.12	0.16	0.12	0.18	0.21	0.24	0.21	0.21	0.20	0.18	0.20	0.16	0.17	0.19	0.18
	CV%		9.63	12.73	12.46	11.85	12.34	12.67	12.91	11.34	12.30	12.28	13.49	13.07	12.94	12.56	12.95	12.08	12.52

* Figures in the parentheses are ($\sqrt{x+0.5}$) transformations, DAA- Days after application

profenophos 50 EC @ 1:4 dilution was significantly inferior among all the treatments.

4.2.4.2.4 Average of first application

The data on pooled means of whiteflies population recorded on 5, 10 and 15 days after application of insecticides presented in table 7, revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the whiteflies population. Among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it in reducing the pest incidence. Amongst the remaining treatments imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best followed by dimethoate 30 EC and malathion 50 EC @ 1:4 dilution which were statistically at par. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning recording the highest whiteflies population at all the time intervals.

4.2.4.3 Second application of insecticides given on 17-07-2014

4.2.4.3.1 Five days after second application

The observations (Table 7) recorded five days after application of insecticides revealed significant superiority of pesticides in reducing the pest population over the untreated control. Among the pesticides, monocrotophos 36 SL @ 1:4 dilution was significantly superior to the rest of the pesticides, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with this treatment. Imidacloprid 17.8 SL @ 1:20 dilution was the next best treatment in reducing the pest incidence and its efficacy was

followed by dimethoate 30 EC , malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Significantly maximum whiteflies population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution (10.43 whiteflies/3 leaves) and it was significantly inferior among the pesticides tested.

4.2.4.3.2 Ten days after second application

It is observed from the data given in table 7 that all the pesticidal treatments were significantly superior over untreated control in reducing the whiteflies population, which was found to vary from 1.33 to 15.63 whiteflies per 3 leaves in various pesticidal treatments. Significantly lowest population of whiteflies was again recorded in monocrotophos 36 SL @ 1:4 dilution than all other treatments, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution with which it was at par. The next best treatments were imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Significantly maximum whiteflies population among the pesticides treated plots was observed in profenophos 50 EC @ 1:4 dilution treated plot.

4.2.4.3.3 Fifteen days after second application

Fifteen days after application of insecticides, the whiteflies population was found to range from 1.50 to 16.77 whiteflies per 3 leaves in various treatments (Table 7). The pesticidal treatments were significantly superior over untreated control in reducing the pest population. Monocrotophos 36 SL @ 1:4 dilution was most effective; while profenophos 50 EC @ 1:4 dilution as least effective. In efficacy, monocrotophos 36 SL @ 1:4 dilution was followed by

oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution and it was at par with it. Maximum whiteflies population among the treated plots was observed in profenophos 50 EC @ 1:4 dilution which is significantly inferior over all the treatments.

4.2.4.3.4 Average of second application

The data on pooled means of whiteflies population recorded on 5, 10 and 15 days after application of insecticides are presented in table 7. Among the pesticidal treatments monocrotophos 36 SL @ 1:4 dilution has appeared as the significantly superior treatment over others except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it in reducing the pest incidence. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides right from the beginning recording the maximum whiteflies population at all the time intervals.

4.2.4.4 Third application of insecticides given on 2-08-2014

4.2.4.4.1 Five days after third application

The data on average population of whiteflies recorded five days after third application are presented in table 7. It is evident from the data that the average number of whiteflies five days after application varied from 1.07 to 17.43 whiteflies per 3 leaves in various pesticidal treatments. All the insecticidal treatments were significantly superior over untreated control in reducing the pest incidence. The minimum population of whiteflies was seen in monocrotophos 36 SL @ 1:4 dilution and thus it was found significantly superior to all other treatments except oxydemeton methyl 25

EC and carbosulfan 25 EC @ 1:4 dilution; which were at par with this treatment. This was followed by imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum whiteflies population (12.60 whiteflies/3 leaves) among the treated plot was observed in profenophos 50 EC @ 1:4 dilution and it was found significantly inferior among all the pesticides tested.

4.2.4.4.2 Ten days after third application

Whiteflies population ranging from 0.57 to 18.10 whiteflies per 3 leaves in various treatments ten days after application of insecticides (Table 7) was found to be less in all pesticidal treatments over untreated control. Among the pesticidal treatments significantly lower and higher whiteflies population was observed in monocrotophos 36 SL and profenophos 50 EC @ 1:4 dilution, respectively. Oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution were next in efficacy to monocrotophos 36 SL @ 1:4 dilution and were at par with each other in reducing the pest incidence. Maximum population of whiteflies among treated plots was again observed in profenophos 50 EC @ 1:4 dilution which was significantly inferior to other treatments.

4.2.4.4.3 Fifteen days after third application

It is observed from the data presented in table 7 that, 15 days after application of insecticides, the whiteflies population was found to range from 0.67 to 18.80 whiteflies per 3 leaves in various treatments. All the pesticidal treatments were significantly superior over untreated control in reducing the pest population. The lowest incidence was

observed in monocrotophos 36 SL @ 1:4 dilution and has emerged as the significantly superior treatment to all others except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution; which were next to monocrotophos 36 SL @ 1:4 dilution in efficacy. The maximum population of whiteflies among the treated plots was observed in profenophos 50 EC @ 1:4 dilution which was significantly inferior over all the treatments.

4.2.4.4.4 Average of third application

The data of pooled means of whiteflies population recorded on 5, 10 and 15 days after application of insecticides presented in table 7 revealed that all the pesticidal treatments were significantly superior over untreated control in reducing the whiteflies population. Among the pesticides tested, monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior to the rest, except oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution which were at par with it in reducing the pest incidence. Among the remaining treatments, imidacloprid 17.8 SL @ 1:20 dilution appeared as the next best followed by dimethoate 30 EC and malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution emerged as the significantly inferior treatment among the pesticides tested right from the beginning, recording the maximum whiteflies population at all the time intervals.

4.2.4.5 Average of three applications of insecticides against whiteflies population

The data on pooled means of population build up of whiteflies at 5, 10 and 15 days after each application of insecticides are given in table 7. Monocrotophos 36 SL @ 1:4

dilution was found to be significantly superior among all the pesticidal treatments, followed by oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution. The next best treatments were imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution. Maximum whiteflies population was found in with profenophos 50 EC @ 1:4 dilution right from the beginning at the all time interval.

4.2.4.6 Comparison of present findings with the previous work

The present findings are in consonance with Bheemanna and Patil (2003) and Venugopal Rao *et al.* (2004). Bheemanna and Patil (2003) have verified stem smearing technique for other insecticides *viz.*, dimethoate, methyl demeton, imidacloprid and it was found effective in controlling sucking pests *viz.*, aphids, jassids, thrips and whiteflies. Venugopal Rao *et. al.* (2004) found that the stem application technique (monocrotophos 1:4 dilution or imidacloprid 1:20 dilution) at 20, 40, 60 days old crop is very effective against sucking pests of cotton.

4.3 Safety of insecticides as stem application against natural enemies

4.3.1 Lady Bird Beetle

The safety of various pesticides given in table 2 under field conditions was judged on the basis of observations recorded on the average number of lady bird beetles per plant present on five randomly selected and tagged plants one day before and seven days after each application of insecticides.

The data on average number of lady bird beetles recorded one day before first application of insecticides are presented in table 8.

The data presented in table 8 showed that average number of lady bird beetles (Grub & Adult) one day before the first application of insecticides varied from 2.73 to 3.73 which were statistically non-significant at 5% level of significance, suggesting that the population of lady bird beetles on cotton was uniform; while before second and third application of insecticides they were significant indicating the population of lady bird beetle was not uniform.

4.3.1.1 Lady bird beetles after first application

Among the treatments (Table 8), LBB population was maximum in the plot treated with malathion 50 EC @ 1:4 dilution (4.80 LBB/plant) which was significantly superior over all other treatments. Dimethoate 30 EC @ 1:4 dilution (4.50 LBB/plant) was found to be next best treatment after malathion 50 EC @ 1:4 dilution. Whereas, rest of the treatments showed population of LBB in merit of their efficacy were imidacloprid 17.8 SL @ 1:20 dilution, profenophos 50 EC, oxydemeton methyl 25 EC and monocrotophos 36 SL @ 1:4 dilution. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of LBB per plant (2.63 LBB/plant).

4.3.1.2 Lady bird beetles after second application

The data on population of LBB after second application revealed that among the treatments (Table 8), LBB population was maximum in malathion 50 EC @ 1:4 dilution (6.70 LBB/plant) which was significantly superior over all other treatments. It was followed by dimethoate 30 EC @ 1:4

dilution (6.27 LBB/plant) being the next best treatment after malathion 50 EC @ 1:4 dilution. Carbosulfan 25 EC @ 1:4 dilution showed lowest population of LBB per plant (3.70 LBB/plant).

4.3.1.3 Lady bird beetles after third application

The data on population after third application revealed that among the treatments (Table 8), LBB population was maximum in malathion 50 EC @ 1:4 dilution (11.20 LBB/plant) which was significantly superior over all other treatments followed by dimethoate 30 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution; which was statistically at par with malathion 50 EC @ 1:4 dilution. Profenophos 50 EC @ 1:4 dilution was found to be the next best treatment followed by oxydemeton methyl 25 EC and monocrotophos 36 SL @ 1:4 dilution. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of LBB per plant (6.70 LBB/plant). However, untreated control recorded highest population of LBB (11.40 LBB/plant).

4.3.1.4 Average LBB after three applications

The pooled mean data of population of LBB revealed that among the treatments (Table 8), LBB population was maximum in malathion 50 EC @ 1:4 dilution (7.57 LBB/plant) which was significantly superior over all other treatments followed by dimethoate 30 EC @ 1:4 dilution which was statistically at par with it. Imidacloprid 17.8 SL @ 1:20 dilution, profenophos 50 EC, oxydemeton methyl 25 EC and monocrotophos 36 SL @ 1:4 dilution were the next best to dimethoate 30 EC @ 1:4 dilution. Carbosulfan 25 EC @ 1:4 dilution showed lowest population of LBB per plant

Table 8: Effect of application of insecticides on natural enemies

Sr. No	Treatment	Dose	LBB/5 plants (Grub and Adult)					Chrysopa/5 plants (Grub and Adult)				
			Precount	First	Second	Third	Mean	Precount	First	Second	Third	Mean
1	Imidacloprid 17.8SL	1:20	2.73 (1.79)*	4.20 (2.17)	5.83 (2.51)	10.57 (3.32)	6.87 (2.71)	1.23 (1.30)	2.50 (1.73)	3.50 (1.99)	6.60 (2.66)	4.20 (2.13)
2	Oxydemeton Methyl 25EC	1:4	3.73 (2.05)	2.97 (1.86)	4.13 (2.15)	7.53 (2.83)	4.88 (2.32)	2.23 (1.65)	1.80 (1.51)	2.50 (1.73)	4.67 (2.27)	2.99 (1.86)
3	Monocrotophos 36EC	1:4	3.67 (2.02)	2.90 (1.84)	4.03 (2.13)	7.30 (2.79)	4.74 (2.29)	2.17 (1.60)	1.70 (1.48)	2.40 (1.70)	4.50 (2.23)	2.87 (1.83)
4	Profenophos 50EC	1:4	3.00 (1.84)	3.23 (1.93)	4.47 (2.23)	8.13 (2.93)	5.28 (2.40)	1.50 (1.33)	1.93 (1.55)	2.67 (1.77)	5.07 (2.35)	3.22 (1.92)
5	Carbosulfon 25EC	1:4	3.47 (1.96)	2.63 (1.77)	3.70 (2.05)	6.70 (2.68)	4.34 (2.20)	1.97 (1.51)	1.57 (1.45)	2.17 (1.63)	4.07 (2.13)	2.60 (1.76)
6	Dimethoate 30EC	1:4	3.20 (1.91)	4.50 (2.24)	6.27 (2.60)	11.08 (3.40)	7.28 (2.79)	2.37 (1.66)	2.67 (1.77)	3.73 (2.05)	6.73 (2.69)	4.38 (2.21)
7	Malathion 50EC	1:4	3.07 (1.89)	4.80 (2.30)	6.70 (2.68)	11.20 (3.42)	7.57 (2.84)	1.57 (1.44)	2.90 (1.84)	4.03 (2.12)	6.77 (2.70)	4.57 (2.25)
8	Untreated Control	-----	3.40 (1.97)	5.53 (2.46)	7.73 (2.87)	11.40 (3.45)	8.22 (2.95)	1.77 (1.50)	3.33 (1.95)	4.67 (2.27)	6.85 (2.70)	4.95 (2.33)
	SE $\pm$		0.14	0.01	0.02	0.06	0.02	0.18	0.01	0.02	0.09	0.03
	CD at 5%		-----	0.02	0.05	0.19	0.07	----	0.04	0.05	0.26	0.08
	CV%		-----	10.29	12.88	13.53	12.23	----	11.89	14.47	17.31	14.55

*Figures in the parentheses are ($\sqrt{x+0.5}$) transformations, DAA- Days after application

(4.34 LBB/plant). Untreated control recorded highest survival population of LBB (8.22 LBB/plant).

4.3.2 Chrysopa spp

The safety of various pesticides given in table 2 under field conditions was judged on the basis of observations recorded on the average number of *chrysopa* per plant present on five randomly selected and tagged plants one day before and seven days after the application of insecticides.

The data on average number of *chrysopa* (Grub & adult) recorded one day before first application of insecticides is presented in table 8.

The data presented in table 8 showed that average number of *chrysopa* one day before the first application of insecticides varied from 1.23 to 2.37 per plant. These observations on occurrence of *chrysopa* one day before the first application of insecticides were statistically non significant at 5% level of significance, suggesting that the activity of *chrysopa* on cotton was uniform; while before second and third application of insecticides they were significant indicating the activity of *chrysopa* was not uniform.

4.3.2.1 Chrysopa after first application

Among the treatments (Table 8), *chrysopa* population was maximum in malathion 50 EC @ 1:4 dilution (2.90 chrysopa/plant) which was significantly superior over all other treatments. Dimethoate 30 EC @ 1:4 dilution was found to be next best treatment followed by imidacloprid 17.8 SL @ 1:20 dilution (2.50 chrysopa/plant) which was at par with it. The next treatments in order of their safety were profenophos 50 EC, oxydemeton methyl 25 EC,

monocrotophos 36 SL and carbosulfan 25 EC @ 1:4 dilution. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of *chrysopa* per plant (1.57 *chrysopa*/plant).

4.3.2.2 Chrysopa after second application

Mean data on population of *chrysopa* after second application revealed that among the treatments (Table 8), *chrysopa* population was maximum in malathion 50 EC @ 1:4 dilution (4.03 *chrysopa*/plant) which was significantly superior over all other treatments. The next best treatment after malathion 50 EC was dimethoate 30 EC @ 1:4 dilution recording 3.73 *chrysopa* per plant. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of *chrysopa* per plant (2.17 *chrysopa*/plant).

4.3.2.3 Chrysopa after third application

Mean data on population after third application revealed that among the treatments (Table 8), *chrysopa* population was maximum in malathion 50 EC @ 1:4 dilution (6.77 *chrysopa*/plant) which was significantly superior over all other treatments followed by dimethoate 30 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution; which were statistically at par with it. Profenophos 50 EC @ 1:4 dilution was found to be next best followed by oxydemeton methyl 25 EC and monocrotophos 36 SL @ 1:4 dilution. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of *chrysopa* per plant (4.07 *chrysopa*/plant). The untreated control recorded highest population of *chrysopa* (8.73 *chrysopa*/plant).

4.3.2.4 Average chrysopa after three applications

The pooled mean data on survival population of

chrysopa after three applications revealed that among the treatments (Table 8), *chrysopa* population was maximum in malathion 50 EC @ 1:4 dilution (4.57 *chrysopa*/plant) which was significantly superior over all other treatments followed by dimethoate 30 EC @ 1:4 dilution (4.38 *chrysopa*/plant) which was statistically at par with it. Whereas, carbosulfan 25 EC @ 1:4 dilution showed lowest population of *chrysopa* per plant (2.60 *chrysopa*/plant) among the treated plots. The untreated control recorded highest population of *chrysopa* (4.95 *chrysopa*/plant).

4.3.3 Comparison of present findings with the previous work

The present findings are in conformity with the result of Gaur *et al.* (1999), who reported that stem application of monocrotophos 36 SL (1:4 dilution) or imidacloprid 200 SL (1:20 dilution) using sms brush at 20, 40 and 60 DAS keeps the crop free from sucking pests upto 10 days without harming natural enemies. Perusal of literature revealed that the references on stem application of insecticides against sucking pests on cotton are not available. Hence, it is not possible to compare the present finding with previous work.

4.4 Yield and Economics

4.4.1 Yield

The cotton kapas yield obtained in different treatments is presented in table 9. The yield was significantly influenced by sucking pests in cotton. Among all the insecticidal treatments, higher kapas yield was obtained in monocrotophos 36 SL @ 1:4 dilution (16.33 q/ha), which was at par with oxydemeton methyl 25 EC and carbosulfan 25 EC @ 1:4 dilution (16.26 and 16.19 q/ha). The next promising

treatment was imidacloprid 17.8 SL @ 1:20 dilution (14.53 q/ha) followed by dimethoate 30 EC (13.50 q/ha), malathion 50 EC (11.15 q/ha) and profenophos 50 EC @ 1:4 dilution (10.29 q/ha). Malathion 50 EC and profenophos 50 EC @ 1:4 dilution were at par with each other. The untreated control recorded lowest yield of 8.22 q/ha.

4.4.2 Economics of treatments

The data on economics of the treatments is presented in table 9. The higher ICBR (1:7.52) was obtained in oxydemeton methyl 25 EC @ 1:4 dilution. This was followed by monocrotophos 36 SL and carbosulfan 25 EC @ 1:4 dilution, while the lowest ICBR was found in profenophos 50 EC @ 1:4 dilution. From the ICBR figures computed for different insecticides tested in the present study, it is reveals that though the treatment involving monocrotophos 36 SL @ 1:4 dilution produced higher yield and net return, ICBR of oxydemeton methyl 25 EC @ 1:4 dilution was high as compared to other treatments. The net profit/ha was highest in the plot treated with monocrotophos 36 SL @ 1:4 dilution (28615 Rs/ha). This was followed by oxydemeton methyl 25 EC, carbosulfan 25 EC @ 1:4 dilution, imidacloprid 17.8 SL @ 1:20 dilution, dimethoate 30 EC, malathion 50 EC and profenophos 50 EC @ 1:4 dilution recording net profit of 4380 Rs/ha.

Similar results were obtained by Thakare *et al.* (2009) who revealed that stem application of monocrotophos @ 1:4 dilution at 15, 30 and 45 DAE and imidacloprid @ 1:20 at 15, 30 and 45 DAE proved most economical, recording maximum yield and net profit.

Table 9. Economics of treatments based on net profit and ICBR

Sr. no	Treatment	Dose	Yield (q/ha)	Gross return (Rs/ha)	Cost of Treatment	Total cost (Rs/ha)	Net Return (Rs/ha)	Net Profit (Rs/ha)	CBR	ICBR
1	2	3	4	5	6	7	8	9	10	11
1	Imidacloprid 17.8SL	1:20	14.53	58120	3655	43655	14465	21585	1.33	5.91
2	Oxydemeton methyl 25EC	1:4	16.26	65040	3775	43775	21265	28385	1.49	7.52
3	Monocrotophos 36EC	1:4	16.33	65320	3825	43825	21495	28615	1.49	7.48
4	Profenophos 50EC	1:4	10.29	41160	390	43900	-2740	4380	0.94	1.12
5	Carbosulfan 25EC	1:4	16.19	64760	3965	43965	20795	27915	1.47	7.04
6	Dimethoate 30EC	1:4	13.50	54000	3670	43670	10330	17450	1.24	4.75
7	Malathion 50EC	1:4	11.15	44600	3675	43675	925	8045	1.02	2.19
8	Untreated control	---	8.22	32880	0	40000	-7120	0	0.82	0

Note: 1. Markert prize of cotton: Rs 4000/ql.

3. Oxydemeton methyl 25EC: Rs 490/l

5. Carbosulfan 25EC: Rs 750 /l

7. Monocrotophos 35EC: Rs 560 / l

9. Cost of cultivation: Rs 40000 / ha

10. Labour rate: 227/day

2. Imidacloprid 17.8SL: Rs 165 / 100ml

4. Profenophos 50EC: Rs 660 / l

6. Dimethoate 30EC: Rs 350 / l

8. Malathion 50EC: Rs 360 / l

7. Labour required for one application: 2.5/ha

5. SUMMARY AND CONCLUSION

The present investigation entitled “Bioefficacy of insecticides against sucking pest of *Bt* cotton as stem application” was carried out at the experimental farm of All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra during *Kharif* 2014. The study was carried out to know the seasonal incidence of sucking pests and effectiveness of insecticides for management of sucking pests along with their effect on natural enemies of *Bt* cotton.

The seasonal incidence of the sucking pests and their relationship with weather parameters was recorded at weekly interval from sowing to harvesting of the crop. Whereas, the field efficacy of seven insecticides *viz.*, imidacloprid 17.8 SL, oxydemeton methyl 25 EC, monocrotophos 36 SL, profenophos 50 EC, carbosulfon 25 EC, dimethoate 30 EC and malathion 50 EC were evaluated through stem application against sucking pests of cotton i.e. aphids, jassids, thrips and whiteflies. The application of these insecticides were done at an interval of 30, 45 and 60 days after emergence. The observations were recorded one day before and 5, 10 and 15 days after application. The impact of these insecticides on natural enemies of *Bt* cotton was also studied in the present investigation. The summary and conclusion of research findings are given in this chapter.

5.1. Summary

5.1.1 Seasonal incidence of sucking pests and occurrence of natural enemies in *Bt* cotton

Observations on seasonal incidence of sucking pests infesting *Bt* cotton were recorded at weekly interval by taking count of aphids on top, middle and bottom leaves of cotton plant.

5.1.1.1 Aphids

The incidence of aphids per 3 leaves ranged from 1.15 to 80.77. The maximum population was recorded in 40th MW. Thereafter, the aphids population was found decreasing upto November. The climatic condition during preceding week was T_{min} , T_{max} , RH-I and RH-II and rainfall where 20.3°C, 33.6°C, 70.4%, 40.7% and zero mm, respectively. The positive correlation was found to exist between aphids incidence and metrological parameters ($T_{min}=0.02$, RH-I=0.14, RH-II=0.08) except T_{max} i.e -0.10 and Rainfall=-0.24.

5.1.1.2 Jassids

Incidence of jassids during experimental period was found to range from 1.77 to 14.95 jassids per 3 leaves. The maximum population was noticed in 32th MW. Thereafter, the pest activity slowly decreased upto 47th MW.

The temperature and humidity during preceding week and the peak activity period were found to range from 22.6 to 29.0°C and 74.9 to 68.6%, respectively. The data on correlation coefficient between pest and weather parameters presented in table 3, revealed that the jassids population was found negatively correlated with T_{max} and Rainfall (-0.32 and -0.11), while positively correlated with T_{min} , RH-I and RH-II

i.e. 0.19 and 0.38 to 0.48, respectively. However, highly significant positive correlation was found with RH-II (0.48) i.e. relative humidity during evening hours.

5.1.1.3 Thrips

The incidence of thrips during experimental period ranged from 1.41 to 50.51 thrips per 3 leaves. The peak incidence of thrips was found in 34th MW. During this period, temperature of preceding week was 21.9 to 31.8°C, humidity 70.6 to 50.6% with 34mm rainfall. The thrips population was positively correlated with $T_{\min}$ (0.16) and Rainfall (0.36); while negatively correlated with $T_{\max}$ (-0.36). However, highly significant positive correlation was found with relative humidity (RH-I=0.45 and RH-II=0.49).

5.1.1.4 Whiteflies

The incidence of whiteflies during experimental period ranged from 1.92 to 29.19 per 3 leaves. After the peak activities, the population was found decreasing. The climatic conditions during the 43rd MW in respect of $T_{\min}$, $T_{\max}$, RH-I, RH-II and Rainfall were recorded as 16.1°C, 29.4°C, 72.6 to 57.0% and zero mm, respectively.

The data on correlation coefficient are presented in table 3. The whiteflies population was highly significantly and negatively correlated with temperature ($T_{\max}$ =-0.48 and $T_{\min}$ =-0.54); while positively correlated with relative humidity (RH-I and RH-II) and rainfall i.e. 0.03, 0.21 and 0.09, respectively.

5.1.1.5 Natural enemies

It is observed that incidence of predators was found

in the range of 1.09 to 19.48 predators per plant. The maximum population was observed in 40th MW. Thereafter, the pest activity slowly decreased upto November. Weather parameters during previous week and peak activity were found to range from 22.2 to 34.1°C, 70.1 to 40.1% RH with zero mm rainfall.

The natural enemies population was found to be negatively correlated with maximum temperature (-0.15) and rainfall (-0.17); while positively correlated with minimum temperature (0.02), morning and evening relative humidity (0.23 and 0.14), respectively.

5.1.2 Effect of stem application of insecticides on sucking pests

The present investigation was carried to study the efficacy of different insecticides against sucking pests of *Bt* cotton as stem application. Three applications were given at an interval of 15 days, the first were given at 1-07-2014, second at 17-07-2014 and third at 2-8-2014. The efficacy of imidacloprid 17.8 SL, oxydemeton methyl 25 EC, monocrotophos 36 SL, profenophos 50 EC, carbosulfon 25 EC, dimethoate 30 EC, malathion 50 EC was determined by recording observations on population of sucking pests at 5, 10 and 15 days after each application.

5.1.2.1 Effect on Aphids

The data on population build up of aphids recorded at 5, 10 and 15 days after each application of pesticides showed the superiority of pesticides over untreated control in preventing the building up of population. Monocrotophos 36

SL @ 1:4 dilution was significantly superior over the rest except oxydemeton methyl 25 EC @ 1:4 dilution and carbosulfon 25 EC @ 1:4 dilution with which it was at par in efficacy.

5.1.2.2 Effect on Jassids

The observations on population build up of jassids recorded at 5, 10 and 15 days after each application of pesticides showed the superiority of pesticides over untreated control in preventing the building up of jassids. Monocrotophos 36 SL @ 1:4 dilution was significantly superior over the rest except oxydemeton methyl 25 EC @ 1:4 dilution and carbosulfon 25 EC @ 1:4 dilution with which it was at par in efficacy.

5.1.2.3 Effect on Thrips

The data on the build up of thrips population recorded on 5, 10 and 15 days after each application of insecticidal treatment showed superiority of pesticides over untreated control in controlling thrips. Monocrotophos 36 SL @ 1:4 dilution was found to be significantly superior over rest of the treatments, except oxydemeton methyl 25 EC, carbosulfon 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution with which it was at par in efficacy.

5.1.2.4 Effect on Whiteflies

The observations on population build up of whiteflies recorded at 5, 10 and 15 days after each application of pesticides application showed the superiority of pesticides over untreated control in preventing the build up of whiteflies.

Monocrotophos 36 SL @ 1:4 dilution was significantly superior treatment over the rest except oxydemeton methyl 25 EC and carbosulfon 25 EC @ 1:4 dilution with which it was at par in efficacy.

5.1.3 Effect of stem application of insecticide on natural enemies

5.1.3.1 Effect on LBB

The observations on population build up of lady bird beetles were recorded at 7 days after each application. Malathion 50 EC @ 1:4 dilution was significantly safer over the rest followed by dimethoate 30 EC @ 1:4 dilution.

5.1.3.2 Effect on Chrysopa

The observations on population build up of *Chrysopa Spp.* were recorded at 7 days after each application. Malathion 50 EC @ 1:4 dilution was found safer than others followed by dimethoate 30 EC @ 1:4 dilution.

5.1.4 Yield and Economics

The yield of *Bt* cotton from each treatment was recorded and converted into quintal per ha. The highest yield was obtained from monocrotophos 36 SL @ 1:4 dilution (16.33 q/ha). Next promising treatments were oxydemeton methyl 25 EC and carbosulfon 25 EC @ 1:4 dilution which were at par with it. Among the pesticidal treatments, higher ICBR of 1:7.52 was obtained with oxydemeton methyl 25 EC @ 1:4 dilution and lowest was from profenophos 50 EC @ 1:4 dilution i.e. 1:0.85.

5.2 Conclusion

- The infestation of aphids on *Bt* cotton ranged from 1.00 to 80.77 per 3 leaves during the season. The first incidence of aphids was noticed during 25th MW. The higher population was observed in 40th MW.
- The population of leaf hopper on cotton ranged from 1.77 to 14.96 per 3 leaves during the season. The first incidence of jassids was noticed during 24th MW. The higher population level was observed in 32nd MW.
- The incidence of thrips on cotton ranged from 1.41 to 50.51 per 3 leaves during the season. The first incidence was observed during 25th MW. The higher population was noticed during 34th MW.
- The population of whiteflies on cotton ranged from 1.92 to 29.19 per 3 leaves during the season. The first incidence was noticed during 25th MW. The higher incidence was observed during 44th MW.
- The population of natural enemies *viz.*, Coccinellids, Chrysopids per plant was found in the range of 1.09 to 19.08. The first occurrence was noticed during 25th MW while the peak population was noticed during 34th MW.
- On the basis of efficacy of various pesticides three applications of monocrotophos 36 SL, oxydemeton methyl 25 EC and carbosulfon 25 EC @ 1:4 dilution is effective in controlling aphids, jassids and whiteflies.
- Similarly, monocrotophos 36 SL, oxydemeton methyl 25 EC, carbosulfon 25 EC @ 1:4 dilution and imidacloprid 17.8 SL @ 1:20 dilution were effective in controlling the cotton thrips.

- Among the different chemical treatments, monocrotophos 36 SL @ 1:4 dilution was found to be most effective for suppression of sucking pests while profenophos 50 EC @ 1:4 dilution found inferior among all the treatments.
- Malathion 50 EC @ 1:4 dilution was found comparatively safer to natural enemies (LBB and *Chrysopa*).
- Among the chemical treatments, the highest yield was recorded from monocrotophos 36 SL, oxydemton methyl 25 EC and carbosulfon 25 EC @ 1:4 dilution by giving the effective control of sucking pests.
- The highest ICBR (1:7.52) was obtained with oxydemeton methyl 25 EC which was followed by monocrotophos 36 SL (1:7.48) and carbosulfon 25 EC @ 1:4 dilution (1:7.04).

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Plate 1: Experimental Field



Plate 2. Stem application technique



Aphids



Jassids



Thrips



Whiteflies

Plate 3. Incidence sucking pests on cotton



Adult and Grub of *Chrysopa*



Adult and Grub of Coccinellids

Plate 4. Natural enemies of sucking pests in cotton